The Development of Quality Management toward Customer Value Creation
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Abstract
The evolving roadmaps of TQM (i.e. Six Sigma and Lean Production) have reached a consensus that creating value to customers is the aim of quality management. However, it is not uncommon that suppliers do not have a thorough understanding of customer value, do not know the methods and tools to enable value creation, or not knowing how to demonstrate suppliers’ competence in creating customer value. Although quality management has provided the fundamentals for creating value, further development is required in order to reduce or close the gap between the strategic and the tactical implications of customer value.

This dissertation describes the development of quality management toward customer value creation in order to reduce the “gap” between value creation as the aim of quality management and the value as perceived by customers. The development of quality management requires a Profound Knowledge of Customer Value (PKCV), guiding principles that enable organisations to gain customer-related knowledge and to take necessary actions in order to create, deliver, and optimise customer value through quality management. The principles of PKCV are: appreciation for a value-creating system, knowledge about customer value modes, theory of improvements, and perceptions.

A central point in the PKCV is Value Modes Effect & Analysis (ValMEA), a concept which connects the higher and the lower level of customer value abstraction by describing that customer value appears in different “modes” in different contexts. This interconnection indicates that customer value is not just a concept that is goals/needs-related (fulfilment of goals or needs) or product-related (linked with a product), but also is competence-related (implying suppliers’ value creation potential). Hence, customer value is both the input and the output of a value-creating system, which “reveals” the bi-directional relationship between quality improvements and customer value. This means that customer value measurements may lead to the identification of improvement opportunities, and suppliers’ efforts in improving quality may influence customers’ perceptions regarding the value of the product.
Through a re-interpretation of the principles of Six Sigma and Lean Production and the adaption of tools to capture customer value, quality management can be further developed toward customer value creation.
### List of appended papers


Co-author statement

Djoko Setijono is the main creator of paper I, II, III, and IV, who introduced the basic ideas (concepts), conducted* data collection and analysis, also wrote and edited those papers.

Professor Jens J. Dahlgaard, who is the co-author of the above mentioned papers, contributed by continuously challenging Djoko’s ideas and giving constructive feedbacks during the writing and editing processes.

* For paper II
Preface

I personally believe that doctoral study is not just about spending four or five years to achieve a PhD degree, but it is a part of a research vision that requires commitment and often long office hours. After several years of hard work in my office at the university and in the factory, I finally reached the first milestone of a long journey as a researcher.

I realised that this dissertation perhaps would never have been written without the encouragements, advices (even constructive criticisms), and assistance of the following people that I am very much in debt to. It was a privilege to know and to learn from all of you.

I would like to thank my supervisor and the co-author of several papers in this dissertation, Professor Jens Jörn Dahlgaard (Linköping University) for his support and willingness to supervise my doctoral research, as well as for his trust on my capability, a student that gave him “headache” sometimes with deadlines and debates about concepts. My next acknowledgement goes to Dr. Dick Sandberg, my supervisor at Växjö University, for his willingness to be my supervisor, his supports, and for his trust on my capability; his goal-orientation and time-awareness did have influence on me. I also would like to thank Professor Thomas Thörnqvist (Växjö University), my examiner, for his support and guidance.

I would like to acknowledge the CEO, managers, staffs, and workers of the case company (their names are not mentioned here due to confidentiality reason) for giving me opportunities and for their contributions when I conducted my case studies. It has been valuable experiences for me and it is my hope that my research gave significant contributions to the company on the continuous improvement journey. I also would like to express my gratitude to Dr. Lars Witell (Linköping & Karlstad University) for his valuable comments during the pre thesis-defence seminar; to the anonymous reviewers of my published papers, and to the editors of scientific journals who have given me the opportunities to publish my works.

The following people also deserved my gratitude because they contributed to the success of my doctoral study in many different ways: Professor
Johan Sterte (Växjö University), Professor Anders Baudin (Växjö University), Professor Kaj Rosling (Växjö University), Dr. Lars-Olof Rask (Växjö University), and Dr. Su Mi Dahlgaard-Park (Lund University).

Last but not least, I acknowledge my parents and siblings for their psychological supports during these study periods.

Växjö, Spring 2008

Djoko Setijono
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1. Introduction

1.1 Background

The definition and discussion regarding the concept of quality in e.g. Zeithaml (1988); Nicholls (1990, 1993); Dahlgaard et al (1998); Hansen (2001); Ulaga and Chacour (2001) embrace the relation between quality and value by, for example, discussing the concept of quality in terms of “value for money”, suggesting that customer value is the fourth phase of quality evolution, and describing the interconnection between perceived quality and perceived value. Although the aim of quality management is to create [customer] value and that TQM studies focus on customer value, “in TQM literature, we note a lack of studies analysing the contribution of quality management to value creation and diffusion in the perspective of stakeholders” (Mele and Colurcio, 2006; p. 467).

According to Khalifa (2004), people have tendencies to define value as one of the following: shareholder value, stakeholder value, or customer value; and customer value is the source of all other values. Hence, the aim of quality management should be first focused on creating value to customers (Nicholls, 1990).

The thoughts by Khalifa (2004) and Mele & Colurcio (2006) can be used to build a reasoning that there is a theoretical “gap” between quality management at a strategic and an operative level, in the sense that although TQM studies focus on customer value, those studies have not yet been directed to the development of quality management in order to enable customer value creation.

Another phenomenon that indicates the “gap” between the aim of quality management (value creation) and customer value is that the operational aspect of Six Sigma and Lean Production in terms of performance measures do not well reflect customer value as their strategic goals (see paper III). This phenomenon may be caused by the fact that value is a very complex concept (Khalifa, 2004; Mele and Colurcio, 2006).

The "gap" between the “means” of customer value (quality management through TQM, Six Sigma, and Lean Production) and the “end” of
customer value (see figure 1) makes customer value creation a complex task, because customer value as an “end” is customers’ perception or state of mind (Khalifa, 2004), which may not be easily understood by the producers, or because producer and customers may have different views regarding customer value (Womack and Jones, 2003; Möller, 2006). This “gap” may explain the scepticisms regarding [total] quality management that it is: too internally oriented (Woodruff and Gardial, 1996) or originated in a systems analysis and not from a profound understanding of customer's purchase motivation and competitor strategies (Maklan and Knox, 1997). However, these scepticisms ought to be carefully examined because TQM is a management philosophy that consists of principles (core values) such as focus on [external] customers and managerial commitment to achieve quality goals in which benchmarking is a part of the commitment (see e.g. Oakland, 1989; Dahlgaard et al, 1998). Zairi (1994, p. 7) formulates that “TQM as a philosophy is fine, provided that we understand its workings and its benefits (which are long term) .... The problem is not really TQM as a philosophy but rather one of attitudes and behaviour [i.e. focus on the “wrong” things and works in a “wrong” way during TQM implementation]”.

![Figure 1. Gap between quality management and customer value](image)

The inconsistency between the producer's and customers' views of value seems to be more apparent by comparing a general situation in North American wood flooring industries which compete based on price but end up on disappointments (in Setijono and Sandberg, 2005) and a study by Erntsson (2002) which suggested that wood-flooring customers would likely be less sensitive on price if they perceived higher benefits. Moreover, based on Jonsson’s (2005) customer survey on different flooring materials, the result (for wood type of flooring material) suggested that good price and durability are product characteristics with the highest importance weight/score. Hence, the study indicated that the customers consider the benefit (in terms of quality) and the sacrifice (or
cost) of wood flooring products when they decide to buy and to install wood flooring, which implies the concept of customer value and the “value for money” concept of quality is real. Hence, we may argue that customer value creation seems to be the most appropriate strategy for wood-flooring producers.

1.2 Research problem

An emerging research stream suggests that customer value is related to suppliers’ competencies (Golfitto and Gibbert, 2006). However, there are not many suppliers know the tools and the processes to develop, improve, promote, and to market their value creation competencies.

Suppliers may find the tools and processes for value creation in quality management, considering that quality is an important component of value (Dumond, 2000) and the aim of quality management is to create value. However, quality reflects customer’s cognitive structure from a lower level of abstraction than value does (Zeithaml, 1988), which supports the reasoning that there is a “gap” between quality management and customer value. Besides, the term customer focus (as a prerequisite of customer value creation) is not easily implemented operationally as well as translated into an effective active throughout the organisation and into the market place (Bathie and Sarkar, 2002) – this difficulty is “shared” by both TQM and marketing. The main concern here is that quality should also reflect customer’s cognitive structure at a higher level of abstraction (by accommodating customer’s perception of value) in order to enable quality management for creating value to customers. As a matter of fact, quality will get positive or negative implications when associated with value (Conti, 2005).

Hence, the following research problem is defined:

How does the further development of quality management lead to customer value creation?

The research problem has both theoretical and practical implications. From a research perspective, it is about the further development of quality management toward a new quality management paradigm; while empirically, it is about understanding customer’s perception of value and
then use the knowledge to manage quality in a way that it creates value for customers. Further, developing quality management to create customer value needs to take into account the “bipolar” definitions of quality, i.e. backward-looking quality (quality in relation to defects, flaws, or deficiencies) and forward-looking quality (quality in terms of positive features or superior characteristics) (Ishikawa, 1985; Kondo, 1993).

1.3 Research questions

TQM’s focus on facts indicates that measurement is fundamental in managing the creation and delivery of customer value (Mele, 2007) where the measurements should, of course, be based on a correct understanding and interpretation of customer value itself. This statement is in line with the term customer value audit (see e.g. Ulaga and Chacour, 2001; Mele, 2007), which is described as a managerial tool to measure or evaluate customer’s perception of value based on customer’s expectation and perceptions of performance, where the evaluations or measurements may indicate a company’s competitiveness and provide input to improve the implementation of TQM (Mele, 2007). Furthermore, the company’s ability to create and deliver customer value cannot exclude the contribution of synergic relationship between TQM and marketing, in which TQM pillars, especially customer orientation, focus on processes, and continuous improvements, are important to “revitalise” marketing theory and practice (Mele, 2007). Thus, this reasoning implies that further development of quality management for customer value creation may comprise the adaption of customer value audit and marketing methods/tools, featured by TQM pillars, in order to manage (measure and improve) supplier’s performance when creating value.

Hence, the above research problem is divided into the following research questions:

1. What is customer value?
2. How does customer value become a basis (foundation) for further developing quality management?
3. How does the further development of forward-looking quality management lead to customer value creation?
4. How does the further development of backward-looking quality management lead to customer value creation?
1.4 Purpose and aim

The purpose of this dissertation is to contribute to the development of quality management toward customer value creation, where customer value is not merely about perceptions of customers in the market but it is also related with the way suppliers absorb and utilise the knowledge about customers and their value in order to manage quality. Managing quality with orientation on customer value will enable suppliers to develop and to market their competencies to create value to customers. Hence, the relationship between quality and customer value is bi-directional, meaning that the way an organisation manages its quality will influence customers’ perceptions of its products, and the information (knowledge) about customers’ perceptions regarding the value of products can be used as input to manage quality in an organisation. To view customer value as customers’ judgments on suppliers’ value creation potential “moves” the notion of value one “step” upward, from product-related to competence-related. It is important for the suppliers that the customers “see” supplier’s value-creation potential because it may influence customers’ appreciations regarding the value of the products.

The dissertation aims to reduce the “gap” between value creation (as the aim of quality management) and customer value (as perceptions or states of mind) by providing guidelines for suppliers to manage quality in a way so it enables customer value creation.

1.5 Limitation

The dissertation mainly discusses customer value in relation with products (referred to as manufactured goods) and manufacturing processes. The term “suppliers” refers to “producers” (“manufacturers”), which are then recognised as customer value-creating systems or organisations. The dissertation further narrows the scope of the discussion by describing the creation of value by a single producer, thus not value creation by a constellation of multiple producers and their suppliers.

1.6 Demarcation

This dissertation describes the development of quality management, in which the term “management” is specified as performance measurements, identification of improvement opportunities (project nomination), and
project selection, thus it does not include the implementation of selected improvement projects.

1.7 Guidelines of the dissertation

This dissertation consists of seven chapters and five appended papers. Chapter 2 contains a critical theoretical review and chapter 3 is a methodology chapter.

The readers can find the answers of the four research questions in the respective chapters as shown in table 1. Each chapter is connected to several papers, which have been written by the author during his doctoral study.

<table>
<thead>
<tr>
<th>Research question</th>
<th>Chapter</th>
<th>Paper</th>
</tr>
</thead>
<tbody>
<tr>
<td>RQ 1</td>
<td>2</td>
<td>Paper I, V</td>
</tr>
<tr>
<td>RQ 2</td>
<td>4</td>
<td>Paper I, II, III, IV, V</td>
</tr>
<tr>
<td>RQ 3</td>
<td>5</td>
<td>Paper I, V</td>
</tr>
<tr>
<td>RQ 4</td>
<td>6</td>
<td>Paper III, IV</td>
</tr>
</tbody>
</table>

Figure 2 visualises the main content of the dissertation (chapters 4, 5, and 6). The “heart” of the dissertation is the Profound Knowledge of Customer Value (PKCV) in chapter 4, where the main messages of PKCV are that producers should have a correct interpretation about customer value and should have active roles in customer value creation. Similar to the System of Profound Knowledge (Deming, 1994), PKCV consists of four principles, where each principle is “tied up” to particular papers. Chapter 4 also suggests the pathway for value creation, where PKCV is the important foundation of the pathway. The process of transforming quality management toward customer value creation is described in chapters 5 and 6. Finally, the last chapter in this dissertation is chapter 7, which contains the conclusions, managerial implications, and suggestions for future research.
Creating Customer Value through Quality Management

Forward-looking quality management
Backward-looking quality management

PROFOUND KNOWLEDGE OF CUSTOMER VALUE

Principle 1
Principle 2
Principle 3
Principle 4

Paper I
Paper II
Paper III
Paper IV
Paper V

RQ 1
RQ 2
RQ 3
RQ 4

Figure 2. Main structure of the dissertation
2. Theoretical review

2.1 The categories of value in management literature

Prior to describing the concept of value, it may be necessary to briefly explain different categories of value. This explanation might be useful to clarify which value that will be referred to in this dissertation and the connection between the different categories of value.

According to Khalifa (2004), management literature on value is usually clustered around three categories: stakeholder value, shareholder value, and customer value.

**Stakeholder value**

Within the concept of stakeholder value, a company is socially responsible to create value not only for its shareholders, but also for its customers, employees, and society at large (Barsky et al, 1999). The orientation towards creating value to stakeholders has been believed as the meaningful purpose of a business in which all stakeholders are given opportunities to determine the future direction of a company (in Khalifa, 2004).

**Shareholder value**

Shareholder value in its essence is cash returns on investments, which is determined by comparing the cash flow return on capital with the cost of capital (Sinha, 2006). In its early development, the concept of shareholder value emphasised more on gaining returns from capital or financial investments. Recently, the emphasis has been shifted towards the view that customers are the driver of those returns (see e.g. Gummesson, 2004; Bauer and Hammerschmidt, 2005; van Raiij, 2005). Thus, shareholder value focuses on the value of customers in generating profit for a company.

2.2 Customer value

Researchers such as Khalifa (2004) and Mele and Colurcio (2006) have “reminded” that customer value is a complex and difficult-to-define concept. Based on the review on customer value literature, it has been reflected that the difficulty and the complexity of the customer value
concept may be caused by the following aspects: the nature (characteristics), the dimensions and types, the level of abstraction, the forms, and the content. These influencing aspects “shape” the definitions, models, and the research direction of customer value. Therefore, it would be useful to first describe these aspects before describing the definition of customer value.

2.2.1 The nature
The complexity and the difficulty of customer value may stem from the characteristics or the nature of customer value, which have been discussed by, e.g. Nicholls (1993), Bounds et al (1994), and Holbrook (1999). Customer value is described as: idiosyncratic (subjective, personal preference), dynamic (changes over time), interactive (between subject and object), situational, and the experience of using or consuming a product. It is not unusual that customer value literature mentions both customer value and consumer value, because customers (e.g. buyers) are not always the consumers (end-users) and what the customers value before buying the product may be different compared to when the customers are using the product. This makes the concept of customer value context-dependent.

2.2.2 The dimensions and types
According to Holbrook (1999), there are three dimensions (broken down into six aspects) of customer value which describe the properties of customer value: 1) extrinsic versus intrinsic, 2) self-oriented versus other-oriented, 3) and active versus reactive. Table 2 briefly explains these three dimensions.

Based on these dimensions, Holbrook (1999) describes eight types of customer value: efficiency, excellence, status, esteem, play, aesthetics, ethics, and spirituality. However, these types of value focus mainly on the consumer and do not capture value in terms of benefits/sacrifices, not applicable in business-to-business context, nor distinguish between “expected” and “actual” value.

Expressing value in terms of benefits/sacrifices can be found in e.g. Zeithaml (1988) and Gale (1994). Woodruff and Flint (2006) distinguish
the desired value from the received value in order to separate between expected and actual value.

Recent development of customer value by Smith and Colgate (2007) suggests that there are four types of customer value: functional (instrumental) value, experiential (hedonic) value, symbolic (expressive) value, and cost (sacrifice) value.

Table 2. The dimensions of customer value

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Explanation of value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extrinsic</td>
<td>Accomplishment of goals or purposes.</td>
</tr>
<tr>
<td></td>
<td>Example: wearing sweater to be warm.</td>
</tr>
<tr>
<td>Intrinsic</td>
<td>Enjoyment of an experience itself.</td>
</tr>
<tr>
<td></td>
<td>Example: attending a music concert.</td>
</tr>
<tr>
<td>Self-oriented</td>
<td>Effect of consumption on oneself.</td>
</tr>
<tr>
<td></td>
<td>Example: when wearing a sweater, then one-self is being warm, not other.</td>
</tr>
<tr>
<td>Other-oriented</td>
<td>Effect of consumption on others.</td>
</tr>
<tr>
<td></td>
<td>Example: when attending a music concert, one may be perceived as an artistic person.</td>
</tr>
<tr>
<td>Active</td>
<td>Entails a physical or mental manipulation of some tangible or intangible objects.</td>
</tr>
<tr>
<td></td>
<td>Example: one should wear the sweater to be warm.</td>
</tr>
<tr>
<td>Reactive</td>
<td>Results of appreciation or admiration of some objects.</td>
</tr>
<tr>
<td></td>
<td>Example: when attending a music concert, one basically does &quot;nothing&quot; but watching and listening.</td>
</tr>
</tbody>
</table>

2.2.3 The level of abstraction

Based on e.g. Zeithaml (1988), Flint et al (1997), Woodruff (1997; in Flint and Woodruff, 2001), and Khalifa (2004), customer value involves both higher and lower level of abstraction. At a higher level of abstraction, customer value is all about customer perception, experience, or even customer personal values. At a lower level of abstraction, customer value is about the attributes or characteristics of products, services, or even suppliers. According to means-end theory (see e.g. Bounds et al, 1993; Edvardsson and Gustafsson, 1999; Hermann and Huber, 2000; Reynolds and Olson, 2001), these two levels of abstraction are not disconnected, but
they are linked to each other through the *consequences* of the product’s use. This implies that there are value components (i.e. product attributes or characteristics) that are (explicitly) *expected*, *dissatisfy* (*value destroyers*), or *delight* (*value magnifiers*) the customers (Kano, 2001; Khalifa, 2004).

### 2.2.4 The forms

In general, customer value involves two basic forms: *trade-off* and *non trade-off*. Customer value can be described as a trade-off between *benefits* and *sacrifices* (e.g. Zeithaml, 1988; Gale, 1994). Both the benefits and the sacrifices are stated in plural form because customer value might be best described as a multidimensional construct even though it is not an absolute condition (Lin et al, 2005). At a lower level of abstraction, there are tendencies to “narrow” the *benefit* as *quality* and the *sacrifice* as *price* or *cost*, which explains different interpretations about customer value. The trade-off form of customer value dominates the discussion of customer value in e.g. industrial marketing, procurement, quality management, and service literature.

Customer value can also be described in a *non trade-off* form, where customer value is the fulfilment of goals, needs, or wants through the consequences of using or consuming products or services. This type of customer value dominates the discussion of customer value in e.g. consumer marketing, psychology, and other social sciences.

Hence, the basic difference between those two forms is that the trade-off form involves *sacrifice* element (monetary or non-monetary), while non trade-off doesn’t.

### 2.2.5 The contents

According to Treacy and Wiersema (1993) and Anderson and Narus (2004), customer value consists of *product leadership*, *customer intimacy*, and *process excellence*, where these elements are likely to be fulfilled through *product*, *service*, and *customer relationship* (in e.g. Lapierre, 2000; Lin et al, 2005). Smith and Colgate (2007) describes that customer value is generated from *information*, *product*, *interaction*, *purchase/consumption environment*, and *ownership/possession transfer*, which are created by different processes and activities within and between organisations.
Fulfilling the elements of customer value requires the producers to produce the goods or deliver the service as well as to interact with customers (before the customers are able to consume the products or services), which should be characterised by speedy response, competitive (low) price, and high quality or premium service (Treacy and Wiersema, 1993) as well as complemented by “soft” aspects such as image, trust, etc.

It might be apparent that when describing customer value in terms of speedy response, low price, and high quality, the context has been “switched” into and focused on production, where customer value basically contains quality, time, and cost elements (Womack and Jones, 1996, 2005; Harry and Crawford, 2005). However, this does not imply that quality, time, and cost are what customer value is all about. Instead, those are what usually (should be) focused on when discussing customer value in the context of production (see paper III for further description, especially figure 1 and 2).

Although time is a component of customer value, the customers may include it as either benefit or sacrifice. On the other hand, suppliers may consider time as an independent variable in the value “equation” since there is transfer of ownership from the supplier to external customers or from internal suppliers to internal customers.

Further descriptions about the contents of customer value can be found in paper I and paper III.

2.2.6 The definitions
The following definitions may provide several clues of what customer value is all about. Zeithaml (1988, p. 14) defines [perceived] value as “consumer’s overall assessment of the utility of a product based on what is received and what is given”. According to Woodruff (1997), customer value is a customer’s perceived preference for and evaluation of those product attributes, attribute performances, and consequences arising from use that facilitate (or block) achieving the customer’s goals and purposes in use situations. Holbrook (1999) defines customer value as an interactive relativistic preference experience. Interactive means that value involves a relationship between the subject (the customer) and the object (the
product). *Relativistic* indicates a customer’s personal comparison of an object to another in different situations. *Preference* refers to the judgement a customer made. Experience implies that value resides in consumption (use) rather than in an object or a possession of an object.

Mele and Colurcio (2006) offer a quite representative explanation of customer value, where customer value is defined as the customer’s achievement of satisfactory experiences of buying and consuming goods and services (p. 484); a customer receives “superior” value if the object (obtained from a firm) fulfils his/her needs and wishes in a more satisfactorily way compared to another object (from another firm) (p. 483).

2.2.7 Reorganising the definitions

“Customers’ achievement of satisfactory experience” indicates that customer value is a *state of mind or experience*, where satisfaction is an important part of value. “Fulfilment of needs and wishes” indicates that the customers *cognitively judge* the object (a good or a service), where the judgment can also be made in comparison with another object (thus the cognitive judgment occurs in the context of competition and non-competition). An object is created (produced) by a firm and then delivered to the customers by the same or a different firm. In order to create and deliver goods and/or services that fulfil what customers want, when, and where they want, a firm needs to posses *competencies* to be *effective*, *efficient*, and to establish and maintain cooperation with other firms in a *network*. Thus, customer value involves a *cognitive judgment on the firm’s competencies* in creating and/or delivering the object. This seminal research has been published as a special issue in the *Journal of Industrial Marketing Management* (vol. 35, issue 8), which thus indicates that customer value is related to the roles of suppliers on creating value to customers.

In order to simplify our view about different concepts of customer value, the different definitions of customer value are reorganised into the following categories:

1. A state of mind (sense of achievement/fulfilment) or an experience
2. A cognitive judgment on product or service
3. A cognitive judgment on suppliers’ (producers’) competence.
The above way of categorising offers a more up-to-date view of customer value, in the sense that it embraces the customer value notion from both higher (on the market side) and lower levels of abstraction (on the supply side). Customer value at the lower level of abstraction (on the supply side) is important because:

- It involves producers (suppliers)
- It establishes connection to quality
- It eventually leads to purchase transaction and customer value at a higher level of abstraction (because customers, in most situations, couldn’t use the product without first buying it).

**Customer value is a state of mind or experience**

Customer value as an experience or a state of mind occurs when the customers use or own the product. Thus, this way of defining customer value is common in *post-purchase* context. At this stage, customer value is the fulfilment of goals, needs, or wants. It is the value that customers “receive” (see Flint and Woodruff, 2001). Customer value may also explain the customer as a person (what he/she values in life). The experience and/or the fulfilment of goals/needs eventually makes the customers feel content or satisfied, which thus implies that a state of emotion also provides a useful explanation of the value concept. This category of customer value definition is usually found in art, psychology, consumer behaviour, etc.

**Customer value is a cognitive judgment on product or service**

This concept of customer value is the most common reference of customer value in the context of purchasing or service, where customer value is usually defined as a trade-off between *perceived benefits* and *perceived sacrifices* (e.g. Zeithaml, 1988; Gale, 1994, Simpson et al, 2001; Lin et al, 2005). Thus, it is usually known as *perceived customer value*. Although it is generally defined as a trade-off between benefits and sacrifices, there are many different versions of what the benefits and the sacrifices may contain, which depend on e.g. the frame of discussion: business-to-business (B2B) or business-to-customers (B2C).

Purchase transactions between supplier and buyer usually involve money in exchange to the object of transaction. This is the reason that customer value can also be expressed in monetary terms as *exchange value*, which is
often simply defined as \textit{price}. In this sense, customer value is the benefits for customers by paying less. However, the concept of price is multidimensional (Padula and Busacca, 2005), which involves a comparison between \textit{selling price} and \textit{willingness to pay}. This multidimensionality of price becomes the motivation to redefine exchange value as a ratio between \textit{utility} and \textit{price} (see paper I), where exchange value is equal to perceived customer value (paper I and II). The equality between exchange value and customer perceived value thus indicates that the economic value of a product reflects customer’s perception about the value of the product. Therefore, producers may predict and monitor customers’ perceptions about the value of products through exchange value. The fact that exchange value is a ratio between two financial measures (i.e. willingness to pay and price) makes exchange value relatively easier to capture than perceived customer value (see paper II). However, exchange value can not be used to replace customer cognitive judgement.

Grönroos (1997) suggests that perceived customer value is equal to \textit{core value} plus minus \textit{added value}. This model is “attractive”, not only in the sense that it provides a different concept compared to other models but also because it develops connection to the producers or suppliers.

\textit{Customer value is a cognitive judgment on suppliers’ (producers’) competencies}

The third concept of customer value describes that customer value is customers’ judgment or evaluation on suppliers’ or producers’ competencies. From the customers’ perspective, competencies are seen as input to customers’ organisational processes that directly create value (Golfetto and Gibbert, 2006). This way of defining customer value is recently “introduced” in the field of, e.g. industrial marketing, where customers use suppliers’ competence profile as the basis for supplier selection (ibid).

Möeller and Törrönen (2003) suggest that these competencies include \textit{efficiency}-related competencies (i.e. cost reduction), \textit{effectiveness}-related competencies (i.e. solution), and \textit{networking} competencies (i.e. access). Möller and Törrönen (2003) further describe that suppliers create the following types of value: \textit{core value}, \textit{added value}, and \textit{future value}. Core
value is created in a transactional supplier-customer relationship or at the early stages of business relationship where the emphasis is on efficiency; while creating added value focuses on effectiveness. On the other hand, future value relies on a network that requires partnership between suppliers and customers. The ability to create value spectrum (that consists of core value, added value, and future value) is dependent on: 1) supplier operational performance (efficiency, flexibility, excellence), and 2) supplier ability to incrementally or radically innovate (Möller and Törrönen, 2003). The concept of future value seems well described by Gummesson’s (2004) theory that customer value creation occurs in network constellations.

The efficiency, effectiveness, and network as the required competencies to create value to customers are very similar to the components of added value (Harry and Crawford, 2005) and the discussion of customer value in Womack and Jones (1996). Thus, it can be argued that added value is a manifestation of customer value in production, which can be linked to perceived customer value (paper III).

From the suppliers’ perspective, suppliers should promote (demonstrate), transfer, and sell their competencies (Gibbert et al, 2006) as well as continuously develop their competencies (Berghman et al, 2006). However, the implication of customer value on suppliers is less understood, such as what are the tools and processes used by suppliers to develop, market, and deliver competencies [to create value]? (Golfetto and Gibbert, 2006; p. 906). The required tools and processes may be found in quality management methodologies considering that quality is an important component of customer value (Dumond, 2000) and the aim of quality management is to create customer value (Mele and Colurcio, 2006). However, the existing tools and methods in quality management need to be further developed to better reflect customer value.

2.2.8 Towards coherent customer value

It has been noticed that prior to a purchase transaction customer value is discussed primarily in the trade-off form. On the contrary, post-purchase customer value is rarely discussed in utilitarian (trade-off) form.
This, to some extent, is correct because customer value is a state of mind, which is independent of monetary or non-monetary sacrifices. However, customers also make judgement on the benefits gained from the product in comparison to the efforts (or money) they have spent to acquire and own the product.

Thus, in this sense, the overall concept of customer value is not yet coherent, meaning that during the use of the product, the benefits are not compared against the [monetary] sacrifices during the period of ownership, i.e. life cycle costs (LCC). To a certain degree, customers take into account the LCC prior to buying transaction. When LCC is perceived as high, customers may not wish to buy the product, and when customers are negatively “surprised” by high LCC, they may be dissatisfied although the product was previously perceived as valuable (having the desired characteristics). In the case of wood-flooring products, the fact that wood flooring has a higher LCC compared to other flooring materials (see Mousatche and Languell, 2001), leads to a prejudice that installing wood floor is costly, which in turns affect the customer’s desire and decision to buy and install wood floors. Therefore, in paper I and V, the LCC is taken into consideration in the customer value concept.

In brief, the hierarchical value map (means-end model, non trade-off form) often only exposes the benefits for customers and not the sacrifices; it does not “reach” the process where the attributes were created. When the means-end model is extended and the sacrifices are defined in terms of costs, it is found (as shown in table 3) that the concept of customer value shows coherence, in the sense that we can find consistencies between different ways of defining customer value (i.e. trade-off versus non trade-off, marketing versus operations management).

Viewing customer value as presented in table 3 influences the way customer value is defined and built in the rest of this dissertation. Table 3 suggests that: 1) the way “benefit” and the “sacrifice” is defined will determine the type of value, 2) although there are different types of value, they are related and they explain how customer value is conceptualised at different stages of product’s life cycle, and 3) the link between quality management and customer value is stronger and more apparent. The
coherence of customer value definitions thus validates the argument that “the aim of quality management is customer value creation”.

Table 3. Coherence in value concepts

<table>
<thead>
<tr>
<th>Value as a non trade-off</th>
<th>Sacrifices (Costs as the denominator)</th>
<th>Value as a trade-off (Utilitarian model)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Values</td>
<td>Consequences</td>
<td>Received Customer Value*)</td>
</tr>
<tr>
<td>Attributes</td>
<td>Attributes</td>
<td>Perceived Customer Value**</td>
</tr>
<tr>
<td>Attributes</td>
<td>Life Cycle Costs</td>
<td>Perceived Customer Value**</td>
</tr>
<tr>
<td>Life Cycle Costs</td>
<td>Price</td>
<td></td>
</tr>
<tr>
<td>Quality (product)</td>
<td>Costs</td>
<td>Value Analysis/Engineering****</td>
</tr>
<tr>
<td>Quality (process)</td>
<td>Non Value-Added Costs</td>
<td>Added Value****</td>
</tr>
</tbody>
</table>

2.3 Quality management

2.3.1 Total Quality Management

Origin and definitions

The term “TQM” was first introduced by John S. Oakland (Oakland, 1989), where he defines TQM as an approach to improving the effectiveness and flexibility of business as a whole – quality in all functional areas. TQM is an “extension” of Total Quality Control (TQC) by Feigenbaum (1956, 1961). The “TQM movement” began to take root from UK, USA, and Canada (Macdonald, 1998; Martinez-Lorente et al, 1998; Page and Curry, 2000) although the origin of TQM can be traced back from the initiatives of Union of Japanese Scientists and Engineers (JUSE) in order to improve the productivity of industries in Japan (by inviting Deming and Juran) after World War II. The efforts and the initiatives to improve quality manifested through Company Wide Quality

*) In the context of non-competition
**) As defined by Gale (1994)
****) See paper III
Control (CWQC) to indicate the Japanese approach of TQC (Ishikawa, 1985; Kondo, 1993).

Researchers in the field of quality management may agree with, e.g. Martinez-Lorente et al (1998), Dahlgaard-Park (1999), that it is not easy to explain what TQM is about due to many different definitions and misconceptions of TQM. However, the following definitions may provide insights of what TQM is:

TQM is a corporate culture [and/or management philosophy] characterised by increased customer satisfaction through continuous improvements with active participation of all employees (Dahlgaard et al, 1998).

It is a management system containing interdependent components (i.e. core values, techniques, and tools) in order to increase internal and external customers’ satisfaction with a reduced amount of resources (Hellsten and Klefsjö, 2000).

Total Quality [Management] is a people-focused management system, which includes systems, methods, and tools, that aims at continual increase in customer satisfaction at continually lower real cost (Evans and Dean Jr, 2003).

Shortly, TQM is an approach to improving the effectiveness and flexibility of business as a whole (Oakland, 1989).

Concepts and contents
Despite the vagueness regarding the definition, there are principles and concepts that can be identified as TQM’s core values. There are many “versions” regarding the description of TQM core values, e.g. Bergman and Klefsjö (1994) and Dahlgaard et al (1998) presented five (5) main principles of TQM (management commitment/leadership, customer and employee focus, focus on facts, continuous improvements, and everybody’s participation/involvement), which are included in Dahlgaard-Park’s (1999) finding that TQM consists of twelve (12) principles. An extensive literature review by Mehra et al (2001) suggests that there are forty five (45) critical elements of TQM’s practice, which can be grouped into five (5) main factors: human resources focus, management structure, quality tools, supplier support, and customer orientation. Mehra et al (2001)
further suggest that the future of TQM will emphasise the following areas: **customer focus, process focus, innovation focus, and environmental focus.** Hellsten and Klefsjö (2000) explain that the *techniques* in TQM are ways of working to reach the values, for example: process management, self assessment, and design of experiment. Meanwhile, the *tools* are useful to analyse data or to support decision making, such as: control chart, process mapping, and Ishikawa diagram.

**Future development**

Based on the finding of Mehra et al (2001), it is clear that focus on customers (market) is an essential aspect of TQM’s present and future practice, which makes TQM an appropriate methodology for organisational change towards market orientation (Yam et al, 2005). Market orientation is defined as a “culture” of customer focus that is systematically and entirely committed to the creation of superior customer value (Slater and Narver, 1994) yet considering the interests of other key stakeholders (Simpson et al 2001). Market orientation is valuable because it focuses the organisation to continuously collecting information about target-customers’ needs and competitors’ capabilities, and using this information to continuously create superior customer value (Slater and Narver, 1995). Thus, marketing orientation may be a precursor to value creation (Simpson et al, 2001). However, TQM (as well as marketing) experience difficulties in implementing *focus on customers* operationally, i.e. operate the concept internally and translate it into effective action throughout the organisation and into the marketplace (Bathie and Sarkar, 2002).

Considering the above definitions of TQM, customer focus has been interpreted as satisfying the needs of customers through quality. However, what might be less understood is that [after comparing between Oliver, 1999 and Eggert and Ulaga, 2004] there are two types of customer satisfaction: satisfaction that is related with *purchase* and satisfaction that is derived from *use*. These two types of satisfaction are similar to the classification by Johnson et al (1995): *transaction-specific* satisfaction (short-run evaluation of a product or service experience) and *cumulative* satisfaction (overall experience with a product or service to date). This explains why various researchers (e.g. Oh, 1999; van der Haar, 2001; Eggert and Ulaga, 2002; Spitteri and Dion, 2004; Liu et al, 2005) regard
customer value as the predecessor of customer satisfaction, and other researchers (e.g. Edvardsson and Gustafsson, 1999; Dumond, 2004; Khalifa, 2004) consider that customer value is the successor of customer satisfaction. Therefore, customer value and customer satisfaction are complementary yet distinct constructs (Woodruff and Gardial, 1996), where customer value is a cognitive construct while customer satisfaction is an affective construct (Eggert and Ulaga, 2002). We may then interpret that customer satisfaction is the effect of value on customers’ emotions. Hence, it may be argued that TQM’s difficulties in operationalising customer focus may be caused by an inadequate understanding of what customers do value when determining quality.

A successful implementation of TQM to improve the company’s quality can not neglect the contribution of performance measurements (Juran, 1993; McAdam and Bannister, 2001; Dahlgaard and Dahlgaard-Park, 2002). In this case, performance measurements should be customer-centred (i.e. reflect TQM as a customer-oriented methodology) and not manager-centred (McAdam and Bannister, 2001). The importance of performance measurement is more obvious because a performance measurement system is a part of the value management framework (Dumond, 2000).

Mehra et al (2001) describe that TQM is a continuous, dynamic, life-long journey. Hence, as a dynamic management philosophy, there are (would be) new, alternative quality roadmaps originated from TQM, such as Six Sigma and Lean Production methodologies (Dahlgaard and Dahlgaard-Park, 2006).

2.3.2 Six Sigma

Concepts and definitions
Linderman et al (2003, p. 195) define Six Sigma as an organised and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates. The method to improve the process is described as define, measure, analyse, improve, and control (DMAIC); for new product and service development, the method consists of the following phases: define,
measure, analyse, design, and verify (DMADV) (see Brady and Allen, 2006).

Six Sigma can be seen both from business and statistical perspectives (e.g. Antony and Banuelas, 2002; Antony, 2004; Kwak and Anbari, 2006). From the business perspective, Six Sigma is a strategy to improve the effectiveness and efficiency of all operations to meet or even exceed customers’ needs and expectations (Antony and Banuelas, 2002) by focusing on those that are critical to customers (Antony, 2002). Statistically, Six Sigma is a measure of quality that strives for defect reduction/elimination based on the application of statistical methods to improve process and reduce variation (Antony, 2002). Hence, Six Sigma is ... an intelligent blending of the wisdom of the organization with proven statistical tools to improve both the efficiency and effectiveness of the organization in meeting customer needs ...(Breyfogle et al, 2001; p. 5) ... that can lead to breakthrough profitability and quantum gains in quality... (p. 25).

Critical aspects/factors
As a project-driven management approach (Kwak and Anbari, 2006), Six Sigma contains aspects such as: financial returns (bottom-line), leadership, human and process, infrastructure (“belt” system), data and facts, statistics (thinking, techniques, and tools) (Antony, 2002). Successful implementation of Six Sigma depends on several key factors (see e.g. Antony and Banuelas, 2002; Banuelas Coronado and Antony, 2002; Kwak and Anbari, 2006). Those factors may include: management involvement and organisational commitment; project selection, management, and control skills; encouraging and accepting cultural change; continuous education and training.

Weaknesses and challenges
Banuelas et al (2005, p. 554) describe that although there is a wider acceptance of Six Sigma in many organisations, Six Sigma literature can be generally categorised as introductory (instead of in-depth case study), aimed at educating people about the elementary principles of Six Sigma and selling it as valuable management philosophy.
In their attempt to answer the question whether Six Sigma contains something new or not, Klefsjö et al (2001) describe that Six Sigma does not particularly contain anything new because Six Sigma’s focus on process and eliminating variation can be found in the works of Edward Deming and Walter Shewhart, or can be traced back from TQM, namely Japan’s quality evolution (Dahlgaard and Dahlgaard, 2006). Klefsjö et al (2001) further argue that the novelty of Six Sigma seems to be on the link between the use of statistical techniques and market-orientation in order to deliver bottom-line financial results or performance. Thus, Six Sigma has been expanding from a statistical-oriented method to a strategy to improve business performance. Its rapid expansion and wide acceptance in industries makes Six Sigma a new phenomenon compared to its original theoretical concept, that well-grounded theories may be needed in order to understand the “new” Six Sigma phenomenon (Schroeder et al, 2007). This may be the reason behind Antony’s (2002, p. 305) statement that [the new] *Six Sigma lacks a theoretical underpinning, which thus causes the gap between theory and practice.*

Antony (2002) described that the limitations of Six Sigma is related to: data availability, investment requirements (for start up and solutions), subjective project selection, assumption of normal distribution, “static” and mostly single critical-to-quality (CTQ), limited application in service, organisational culture and learning. However, these limitations provide challenges for future research.

According to Kwak and Anbari (2006), the obstacles and challenges of Six Sigma are as follows: 1) Six Sigma is not a universal answer to all business issues, thus adopting Six Sigma requires analysis and acceptance on its strengths and weaknesses, 2) Six Sigma is not just about problem solving in manufacturing, but also about quality planning and change management, and 3) Six Sigma training should be tailored according to organisational needs and balance between qualitative and quantitative aspects.

The weaknesses of Six Sigma is even more obvious if we compare between the performance measure (i.e. number of defects per million opportunities or *dpmo*) and the goal of Six Sigma, i.e. creating and delivering customer value (Breyfogle et al, 2001), as well as that the *dpmo*
is not always applicable at a corporate level or in service-oriented companies because it is not always easy to define and count defects (George, 2002). Therefore, in paper III, an attempt has been given to improve the consistency between the performance measure and the goal of Six Sigma by suggesting *added value* as a complementary performance measure for Six Sigma, which is demonstrated through a case study in a Swedish wood-flooring manufacturer.

2.3.3. Lean Production

Definitions and principles

Lean production is a methodology that focuses on making the product (goods) flow through a value-adding process without interruption; a "pull" system that cascades back from customer demand by replenishing only what the next operation takes away at short intervals, and a culture in which everyone is striving continuously to improve (Liker, 2004). Lean production methodology consists of the following five steps: defining customer value, defining the value stream, making it flow, pulling from the customer back, and striving for perfection (Womack and Jones, 1996).

Goal and approach

Transforming materials into products creates value (Gummesson, 2004). However, during the transformation process, there are activities that do not contribute to value creation but trigger costs. Therefore, Lean Production methodology defines that *added value* is the actual transformation process or the core process that the customer is paying for, and everything that is not a part of the core process actually does not add value to the customers and will therefore be regarded as "waste" (Liker, 2004). The waste or non-value added could further be classified into *necessary waste* (e.g. inspections, control systems to check that procedures are being followed, documentation) and *pure waste* (e.g. failures, reworks). Hence, the main goal of Lean Production is to provide customer value (Womack and Jones, 1996, 2005; Hines et al, 2004) by continuously driving out those activities that do not add value to customers (*waste*).

Weakness

Although the “strategy” of Lean Production methodology is to create value, its application at the operational level does not apply the principle (Hines et al, 2004), in the sense that to what extent the value provided is
unknown. Instead, the “success” in providing customer value is measured through cycle time, under the assumption that the reduction or elimination of waste will create a smoother flow and thus a shorter cycle time. This is an example of weak linkages between lean production constructs (the philosophical orientation) and measurement variables (the tools/measurements) (in Shah and Ward, 2007). To fill in this theoretical gap, a metric to measure added value in a process is suggested in paper III, and then applied in a Swedish wood-flooring manufacturer.

Future development
Although the reduction or the elimination of “waste” plays a significant role in customer value creation, defining customer value as merely elimination of waste may distort the concept of customer value itself. Therefore, Womack and Jones (2003, 2005) further recommend challenging the "traditional" definition of value in Lean Production and fundamentally rethink value from the perspective of customers. Value can only be specified by the ultimate customers, but the producers need to define and express customer value in terms of a specific product with specific capabilities (that customers need or want, not the producer want to make), offered at a specific time and price (Womack and Jones, 1996; 2003).
3. Research methodology

A methodology is a model, which entails theoretical principles as well as a framework that provides guidelines about how research is done in the context of a particular paradigm ...it translates the principles of a paradigm in a research language and shows how the world can be explained (Sarantakos, 1993; p. 30). Methodology is related to the development of personal insight and understanding in the creator of knowledge, it is the understanding of how methods are constructed and how operating paradigm is developed (Arbnor and Bjerke, 1997).

Operating paradigm, which consists of methodical procedure and methodics, provides “connection” between methodological approach and area of study. Methodical procedure is about adapting technique to a methodological approach, whereas applying this adaption in a plan and/or an implementation is called methodics.

3.1 The system methodological approach

Definition and logic
A system is a set (an assembly) of related components (elements). System reality is assumed to consist of components that are mutually dependent on each other, which means that they cannot be “summed up”, i.e. the whole is more (or less) than its parts.

The constitution of these components brings about synergistic effect, meaning that information is provided not only by the content of individual components but also through the way those components are put together (Arbnor and Bjerke, 1997). In order to explain or understand an individual component, it must be put in context, not just studying the component itself in isolation.

The system approach is a way of thinking (Checkland, 1981), a practical philosophy, and a methodology of change in which the pieces of our fragmented world can be reassembled and coherence can be created out of chaos (van Gigch, 1978). System approach is an attempt to combine theory, empiricism, and pragmatics and looks at a system from the top down rather than from the bottom up (Skyttner, 2001). System approach denies the usefulness of looking for causal relations. Instead, the
researcher looks at the interaction among the components and the forces that influence the system as a whole, where the “cause” is subsequent in time to the “effect”, like the consequence of a certain action or behaviour. System approach argues that the structure and behaviour of a system are determined by its purposes (teleology).

System approach operates in an integrated framework of modern organisational knowledge and management science, where terms such as interrelationship & interdependence, holism, input & output may describe what system approach is all about (Skyttner, 2001).

According to van Gigch (1978), the system approach can be regarded as: 1) a methodology of design, 2) a common conceptual framework, 3) a new kind of scientific method, 4) a theory of organisation, 5) systems management, 6) a method related to systems engineering, operation research, cost effectiveness, etc, and 7) applied general system theory.

System approach and general system theory, from which it derives, encouraging the development of new kind scientific method embodied in the system paradigm that can deal with processes such as life, birth, death, evolution, adaptation, learning, motivation, and interaction (van Gigch, 1978). General system theory investigates the concepts, methods, and knowledge pertaining to the fields of systems and system thinking.

**Analogy, language, and interpretation**

System researchers use the experience and the result from earlier studies only as a mental inspiration for analogies when they conduct studies of systems with similar orientation and content (Arbnor and Bjerke, 1997) or in order to gain some point of leverage on the complexity (Weinberg, 2001). Systems approach does not lead to the creation of a general, absolute theory or knowledge for the components of a model nor for the way such components must be structured or behave, but theoretical knowledge becomes related to one or several types of system or to specific systems phenomena (system-dependent knowledge).

System approach has, to a large extent, a language of its own that consists of a number of concepts that are specific to the approach, where the creators of knowledge occasionally renew the system language by
inventing new concepts that in their opinion provide a better (or more comprehensive) picture of what is going on in the framework of the object under study, perhaps because system creators of knowledge make no clear distinction between their interpretations and those held by the subject in questions.

Data, reliability, validity, and generality
The system approach uses secondary material and primary material from direct observations and interviews as well as *experiments* in a trial-and-error sense (Arbnor and Bjerke, 1997).

Theory building, models, and measurements are common aspects to be found in system approach. However, measurements in system approach are not precise and also not considered worth aiming for. The emphasis is on what a measure can be used for, which may be the reason why the concept of reliability is rarely used.

Because of the lower degree of generality and absoluteness of system theory, the connections among theory, definitions, and reality are not very strong. The requirement is not so much that definitions must correspond with existing theory or to be operational. A common system approach procedure to address validity issues is to reflect the real system from as many angles as possible by being in the real system as long and as often as possible, talking to as many people as possible, and studying as much secondary material as possible.

A system-based person trying to create knowledge perceives his/her reality as consisting of systems, which by definition means dependent relations on one hand and partly unique cases on the other hand. Thus, it is common to work with historical studies and case studies.

Before explaining case study, it may be worth describing quantitative and qualitative research.
3.2 Quantitative and qualitative research

3.2.1 Quantitative research
Quantitative research is social research methods that rely upon numerical and statistical methods, thus associated with the terms “ positivism” and “ empiricism” (Yates, 2004). Quantitative research is characterised by surveys and experiments, where the goal is to produce general statements or “ laws” (nomothetic).

The validity of quantitative research depends on internal validity (ability to draw correct conclusion from the data), external validity (ability to draw accurate inferences from the sample data to other persons, other settings, and past or future situations), statistical validity (ability to draw accurate inferences from the data because of adequate statistical power or fulfilment of statistical assumptions), and construct validity (ability to draw accurate inferences due to the use of adequate definitions and measures of variables) (Creswell, 2003). In quantitative research, cronbach alpha statistic can be used as a reliability check for the internal consistency.

3.2.2 Qualitative research
Qualitative research is research that uses any methods that rely upon primary source information, where very often the “data” is not numerical (Yates, 2004). In many cases, qualitative research crosses these boundaries: phenomenological (emphasises on inter-subjective human interaction), hermeneutic (focuses on the meanings of objects and actions), and relativist positions (existence of a single “reality” or “truth”). Overall these positions can be described as “idealistic”, i.e. prioritise or focus upon the ways in which “ideas” are made and used, contra to the positivists who focus upon the observation of “empirical” events and in turn describe most of types of other activity as metaphysical. Most qualitative works fall into idiographic (detail description of particular circumstances), where the data can be collected in using interviews (in-depth, focus group) or ethnographic fieldworks (collection of qualitative data from a range of contexts). The themes, patterns, understandings, and insights that emerge from fieldwork and subsequent analysis are the fruit of qualitative inquiry (Patton, 2002).
In qualitative research, validity analysis is conducted in order to determine whether the findings are accurate from the standpoint of the researchers, participants, or the readers, i.e. trustworthiness, authenticity, and credibility, using methods such as triangulation, member checking, bias clarification, external audit, etc. (Creswell, 2003), refutability principle, constant comparative methods, comprehensive data treatment, deviant-case analysis, and using appropriate tabulations (Silverman, 2000). Reliability of qualitative research can be performed by documenting procedures and demonstrate that categories have been consistently used, although it plays a minor role (Silverman, 2000).

3.3 Case study

Case study is a research method that cannot easily be classified as either quantitative or qualitative. According to Bryman and Bell (2003), case study employs both qualitative and quantitative research, which makes the classification of case study as qualitative research inappropriate. The term case study refers to the identification of a specific form of inquiry or the investigation of one or a few cases in a considerable depth, which contrasts with two other influential kinds of social research, i.e. experiment and survey (Gomm et al., 2000). Case study research is systemic and holistic, aimed to give full and rich accounts of the relationships and interactions between a host of events and factors (Gummesson, 2005).

Case study is the method of choice when the phenomenon under study is not readily distinguishable from its context (Yin, 1993), which does not imply any particular form of data collection (i.e. quantitative or qualitative). It is an appropriate method to answer “how” and “why” questions, in which the investigators desire to: 1) define broadly and not narrowly 2) cover contextual conditions and not just the phenomenon of study 3) and rely on multiple and not singular sources of evidence (Yin, 1993).

Case study research provides the researcher with an input of real world data from which concepts can be formed and propositions and theory can be tried (Gummesson, 2003, 2005). It can be exploratory (e.g. to define questions and hypotheses, to determine the feasibility of research procedures, and explain cause-effect relationship) or descriptive
(presenting a complete description of a phenomenon within its context) (Yin, 1993). Action research is the most demanding and far-reaching method of doing case study research (Gummesson, 2000). Generalisation may not be the first priority in case study research, but case study researchers are expected to properly describe the case in such a way that it captures its unique features (Gomm et al, 2000).

Gummesson (2003) argues that the validity and reliability of case study should be examined in the same way as examining the validity and reliability of qualitative method. On the contrary, Yin (1993) argues that the way of examining quantitative method is also applicable for case study.

### 3.4 The research process

#### 3.4.1 Structure and framework

The structure of my research (figure 3) began with “organising” the complexity of the customer value concept by describing several aspects that contribute to the complexity of customer value before describing the definitions of customer value itself. Then, I reorganised and discussed the definition of customer value into three categories. Reorganising the customer value concept in this way influenced the way customer value was viewed in my research (i.e. that customer value as perceived by customers in the market is interrelated to the way customer is understood at the supply side). Considering the research purpose, I developed a research framework (figure 4) and (with the research limitation in mind) then determined the focus of my research.

The research structure made me aware that customer value as perceived by customers in the market cannot and should not be separated from the value on the supply side because an object, in which its value is to be perceived by customers, is produced by producers (on the supply side). I described the argument and the reasoning for this through the concept of Value Modes Effects and Analysis (ValMEA) in paper I, which proposed a general view of how various customer value definitions are interrelated.
Customer value
(characteristics, dimensions, forms, levels of abstraction, contents, and definitions)

Reorganise the definitions

Research view

Research framework

Research purpose

Research limitations

Research focus

Figure 3. Research structure

Values

Attributes

Processes

Non-values (waste)

Production

Forward looking

Backward looking

Figure 4. Research framework
The intention of ValMEA has been to provide a simple, comprehensive view of how various definitions of customer value in different contexts might be related because existing publications (see for example Zeithaml, 1988; Oh, 1999; Desarbo et al, 2001; Spitteri and Dion, 2004; Tam, 2004) mainly highlighted how value is connected to, e.g. quality, image, loyalty, etc (depending on the context and scope of the study). The models usually accommodate only one specific type of value, such as perceived [customer] value and there are cases where value is defined in a general term. I could not yet find a model and/or an explanation regarding how various definitions of value can be put in a coherent constellation.

That was the reason why ValMEA only shows how various “types” of customer value can be arranged. Without underestimating elements such as quality, image, and loyalty, these components were “hided” because there have already been many models in different areas/contexts of study (e.g. European Customer Satisfaction Index (ECSI) model) describing or suggesting the connection of those elements with customer value.

In paper I, it was considered as necessary to discuss customer satisfaction in ValMEA because satisfaction is needed to link between perceived- and received customer value. Thus, the “chain” will be “broken” if customer satisfaction was not discussed.

Hence, customer value in different contexts can be regarded as the components of a value system, in which these components are interrelated and interact to each other (explained later by figure 12 in sub-section 4.2.1).

Based on the framework in figure 4, my research has generated five (5) papers, as described by table 4. It might be apparent (from table) 4 that my research has been primarily about theory building. That was the reason why I first developed the theories and then tested those which are related to the creation of value through backward-looking quality management in a Swedish wood flooring manufacturer.
Table 4. Research results

<table>
<thead>
<tr>
<th>Paper</th>
<th>Research purpose/aim</th>
<th>Research methodology/method</th>
<th>Research types</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>To describe different versions of customer value, as well as to develop a method for measuring customer value</td>
<td>Qualitative method, literature review</td>
<td>Theory building, theory driven, exploratory</td>
</tr>
<tr>
<td>II</td>
<td>To develop and to test the proactive measurements of quality costs</td>
<td>Case study, literature review</td>
<td>Theory building, explanatory, theory testing, theory driven</td>
</tr>
<tr>
<td>III</td>
<td>To clarify the link between added value and perceived customer value, as well as to present a method to measure added value</td>
<td>Qualitative method, literature review</td>
<td>Theory building, theory driven, exploratory</td>
</tr>
<tr>
<td>IV</td>
<td>To present a method to nominate and select improvement projects that are perceived as adding value</td>
<td>Qualitative method, literature review</td>
<td>Theory building, theory driven, exploratory</td>
</tr>
<tr>
<td>V</td>
<td>To develop a method to measure and monitor customer value based on customer knowledge</td>
<td>Qualitative method, literature review</td>
<td>Theory building, theory driven, exploratory</td>
</tr>
</tbody>
</table>

Testing the developed theories regarding value creation through backward-looking quality management took the *perceived customer value* as the point of reference. This reference point was then used to develop an understanding that a producer may capture the extent customers found (perceive) an object (a product) as valuable is through *exchange value*, although exchange value cannot replace and should not be used as a substitute to customers’ cognitive judgement. By modelling the dynamics of perceived customer value and exchange value (paper II), it was found
that creative (valuable) quality improvements became the mechanism to improve the way customers perceive the value of a product. This understanding is important when conducting research on *added value* and understanding its link to perceived customer value.

The notion of *added value* (see e.g. Womack and Jones, 1996; Harry and Crawford, 2005) dominates the discussion of customer value in the context of production processes. However, the link between added value and perceived customer value, in my view, has not been well conceptualised yet. Therefore, this link was first conceptualised (figure 2 in paper III) in order to provide a frame of reference of how the added value metric has been formed and tested.

Figure 5 below shows that Ulaga’s (2003) *value dimensions* may be a useful “source” when defining the *first-order variables*. These variables are then usually classified as *benefits* or *sacrifices* (second-order variables).

![Figure 5](image_url)

*Figure 5. Reorganising the components of perceived customer value*
Instead of benefits-sacrifices classification, the second-order variables represent “quality”, “time”, and “price” (or “cost”). These new categories are able to capture and show consistency with how the concept of added value has previously been defined. Another useful “source” for defining the first-order variables can be found in Lapierre (2000), which has been described by figure 1 in paper III.

The quality cost and added-value performance measures are important parts of roadmaps for selecting reactive and proactive improvement projects (see figure 1 and 2 in paper IV).

**3.4.2 Some reflections on the research process**

Since interconnection or interrelatedness is central in the system methodological approach, the concept of Value Modes Effect and Analysis (ValMEA) plays a significant role in my contribution to the development of quality management, by presenting arguments that customer value is not solely about customers’ perceptions in the market nor it is mutually exclusive to how it is understood on the supply side. This “new” understanding was then manifested as the Profound Knowledge of Customer Value (inspired by Deming’s (1994) System of Profound Knowledge), in which the “essence” of customer value was captured and used for “revitalising” quality management. The System of Profound Knowledge and the Profound Knowledge of Customer Value implicitly indicate that the system approach has been important in the continuous development of quality management.

The system methodological approach gave a sensible explanation when I chose a certain language, terms, and concepts to use. A good example is when I defined (viewed) customer value in the market as perceived customer value and received customer value although both are perceptions (in purchase and use contexts respectively). The reason why customer value in the purchase context was not named, e.g. “ideal” customer value, “anticipated” customer value, or even “desired” customer value, was that I adapted the term customer perceived value (a well-grounded term mainly in purchasing and service literature) into “own” language yet without being too deviant from its original term. In fact, Huber et al (2001) use the term perceived customer value, and received customer value can be found in van der Haar et al (2001).
Analogy and inspiration well described an emerging term such as *perceived added value* in comparison with *added value*.

A similar reasoning might also apply when it regards reinterpreting the principles of six sigma and lean production, which may be explained as a consequence of applying system methodological approach (i.e. analogy and inspiration) and/or due to the reason that my research has adapted qualitative method, a research strategy that is influenced by *hermeneutics* (interpretation) and *phenomenological* (not “taking things for granted”) views/approaches.

The developed and described models and measurements in this dissertation are not necessarily “perfect”. However, those models and measurements give representations (insights) of the way customer value in different contexts are consistent and interconnected to each other.

### 3.5 Design of empirical studies

My supervisor and my examiner helped me to initiate a contact with a Swedish wood-flooring manufacturer (Spring 2004) to explore the possibilities of conducting research on customer value-driven quality improvements. The company then expressed their interest to be involved in the research.

During a meeting in October 2004, the company’s representatives described the current situation in the case company, followed by discussion. At the end of the meeting, the company’s representatives communicated their interest to identify and measure the *costs of poor quality* (COPQ), and thus requested me to conduct the study. Given this starting point, I decided to first focus on backward-looking quality management when conducting the empirical part of the research.

Focusing first on backward-looking quality management does not contradict to the theory because, according to Kondo (1993), the quality of the process should first be improved before improving the quality of product design. Conducting research about customer value in a Swedish wood-flooring manufacturer that focused on backward-looking quality management involved the following two studies. It took approximately
two years (Fall 2004 – Fall 2006) to conduct these studies from start to the end.

3.5.1 Study 1

The main purpose of the case study was to test the value of a quality improvements model (i.e. proactive quality cost measurements) and then identify improvement opportunities based on the quality cost measurements. In this study, the company was the unit of analysis.

The application of the model required an operating definition of a quality performance indicator and selecting a model to identify and measure quality costs. The yield (i.e. fraction of conforming products) of 15 mm wood flooring products was chosen as the operating definition of quality performance, and the Prevention-Appraisal-Failure (PAF) model according to British Standard (BS) 6143 was selected as a method to identify and measure quality costs. The process of identifying and collecting quality consists of the following steps: define, streamline, identify, and allocate (see paper II for details).

The improvement opportunities were identified by analysing the quality cost figures and internal defect reports between January and April 2005. In order to get a thorough analysis, 100 (one hundred) samples of 15 mm, one-strip, oak flooring boards were examined. This “experiment” was used as a complement to the quality cost and defect analysis.

In order to ensure that the selected improvement project had a strong connection with business strategy and customer needs, several (informal, dialogue-like) interviews with managers (i.e. sales manager, product manager, quality manager, and manager of technical support) were conducted.

3.5.2 Study 2

The main purpose of the case study was to test the applicability of the added value metric, finding improvement opportunities, and demonstrating the selection of proactive improvement projects. A production line was the unit of analysis, where the study was conducted according to the following steps:
Step 1: Determine the process and its boundaries
it was suggested that the observed process should be relatively simple. The quality manager at the case company suggested that the production line of Linnea or thin wood flooring products (7 mm) should be observed because:

- The production flow is relatively simpler compared to the flow of 15 mm wood flooring products
- According to the production planner, the cycle time of thin wood flooring boards is generally longer than 15 mm products, and
- The 7 mm products generally have tougher quality requirements than 15 mm products.

After conducting visits to the production floor and having had discussions with the staff and the manager of the quality department, it was agreed that the process starts from received goods and continues until the goods are ready for final inspection. The way we defined the process was motivated by the fact that along this process there are important activities which add value to the customers by:

- Making the appearance of wood flooring boards more attractive through several surface treatment processes, and
- Enabling glueless installation through profiling.

Thus, we may call the defined-process as the attractive wood-flooring creation process. The activities to create the primary function of wood flooring are outsourced to some companies in Poland.

The scope of the study was further narrowed by particularly looking at 2-stripe thin wood flooring products made of walnut wood species (article number 372085VA) because according to a previous investigation that I have conducted, this product is among the products that have inferior production rates at both surface treatment and profiling, and the product has considerably higher percentage of defects.

Step 2: Map the process
The process starts after the wood flooring boards (semi-finished goods) are received and put in storage. These boards are then transported to surface treatment, when there are production orders. Sometimes the boards need to wait before processing. Upon completion of the surface treatment
process, the boards are then transported and put in a buffer, waiting to be profiled. After profiling, the boards are transported again for storage and waiting before transportation to final inspection. Both surface treatment and profiling are automated processes.

Step 3: Determine whether a process or an activity is adding value or not

The seven criteria of waste (i.e. overproduction, waiting, unnecessary transport or conveyance, over production or incorrect processing, excess inventory, unnecessary movements, and defects) become the guideline to determine whether an activity or process adds value or not. Along the value stream waste may occur:

- **Between processes**, e.g. unnecessary handlings/transports, delays, and excess storages
- **Within a process**, for example stoppages, breakdowns
- **Within operators' activities** such as waiting, failure investigations and repairs [in this study, the term "operators" refers to the production workers whose work are related to the surface treatment and profiling processes].

Different operators' activities were listed and the duration of each activity was estimated, by conducting preliminary work sampling (see e.g. Tsai, 1996). During a 3-day period of sampling, 89 samples (observations) were collected where 4 operators in the surface treatment process and 2 operators in the profiling process were asked what they were doing at a certain point of time. The result of this preliminary work sampling enabled the identification of what the operators are doing, if and which of their activities were value-adding and which activities did not.

In order to get a better approximation regarding the proportion of operators' activities which did not add value, work sampling need to be conducted during a longer time period, which means that a more accurate approximation requires a larger sample. According to Tsai (1996), the required number of samples is:

$$N_S = \max_{i=1,2,...,k} N_i = \max_{i=1,2,...,k} \frac{Z^2_{1-(\alpha/2)} * p_i * (100 - p_i)}{\bar{A}^2}$$

(1)
Where:

\[ N_S : \text{The required number of samples} \]
\[ N_i : \text{The required number of samples for activity } i \]
\[ Z_{1-(\alpha/2)} : \text{The } z\text{-value of the normal standard distribution at } (1-(\alpha/2)) \text{ confidence level} \]
\[ p_i : \text{The percentage of activity } i \text{ of total operators time} \]
\[ A : \text{The desired level of accuracy} \]

Table 5 shows the result of the preliminary work sampling and the sampling requirements for each activity (at 3% desired level of absolute accuracy and 95% confidence interval).

<table>
<thead>
<tr>
<th>Activity</th>
<th>Observed</th>
<th>Percentage (p)</th>
<th>Required sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Added value</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing-related</td>
<td>8</td>
<td>9.00</td>
<td>364</td>
</tr>
<tr>
<td>Preventive (precautionary)</td>
<td>10</td>
<td>11.23</td>
<td>443</td>
</tr>
<tr>
<td>activities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Non value added (necessary)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setting up</td>
<td>17</td>
<td>19.10</td>
<td>687</td>
</tr>
<tr>
<td>Monitor production</td>
<td>20</td>
<td>22.47</td>
<td>774</td>
</tr>
<tr>
<td>Testing and control</td>
<td>17</td>
<td>19.10</td>
<td>687</td>
</tr>
<tr>
<td>Investigate and repair failures</td>
<td>3</td>
<td>3.37</td>
<td>145</td>
</tr>
<tr>
<td>Administrative</td>
<td>7</td>
<td>7.86</td>
<td>322</td>
</tr>
<tr>
<td><strong>Pure waste</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waiting</td>
<td>5</td>
<td>5.62</td>
<td>236</td>
</tr>
<tr>
<td>Away (cannot be contacted)</td>
<td>2</td>
<td>2.25</td>
<td>98</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>89</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

The required number of samples for the actual work sampling is then the maximum number of samples determined from each activity, which is 774 sampling observations. The actual work sampling was conducted for two weeks in May and in August, where 6 operators were asked what they
were doing 10 times per day (5 times in the morning and 5 times during the afternoon).

Step 4: Measure quality performance
The company’s surface treatment and profiling processes are automated, which is why the measurement of quality performance is based on final inspection after the profiling process, although the operators also check samples of products after each process.

However, in this study, the measurement of quality performance has been done as described in figure 6. Prior to the surface treatment process, there are \( d_0 \) non-conforming wood-flooring boards, which cannot be processed. During the surface treatment process, \( r_1 \) pieces of wood flooring boards need to be re-processed and there are \( d_1 \) wood flooring boards that do not conform to the specifications at the end of the surface treatment process. Similarly, there are \( r_2 \) wood-flooring boards that should be re-profiled and there are \( d_2 \) non-conforming wood-flooring boards after the profiling process. Measuring quality performance according to figure 6 allows the estimation of overall process quality as well as the incoming quality.

The yield after the last process can be used to approximate the average yield of any process in \( k \) serial processes before producing the final yield (\( y \)). This logic is known as normalised yield (Harry and Schroeder, 2000). The average yield in any of serial processes (\( y_{\text{average}} \)) is:
\[ y_{\text{average}} = (y)^{\frac{1}{k}} \]  

(2)

Thus:

\[ d_{\text{average}} = 1 - y_{\text{average}} \]  

(3)

Where:
- \( y \): the yield after the end of the process
- \( k \): number of serial processes
- \( d_{\text{average}} \): average defect rate in one of the serial processes

**Step 5: Measure time performance**

In order to measure time performance, the *value-added time* and the *cycle time* were measured using *time study*, where time measurements of five (5) production batches were collected each month in May and August 2006.

**Step 6: Measure non value added costs**

Measuring non-value added costs using *Activity Based Costing* (ABC) in this study actually does not differ significantly from measuring the "usual" *costs of quality*, except that:

- It requires an identification of the *cost object*
- Each element of non-value added costs should be able to capture the notion of waste
- The *cost driver(s)* of each cost element should be determined. Cost object is the output of a cost system for which activities are performed, e.g. products, services (Cooper et al, 1992), while cost driver is a quantitative measurement of an activity (Kaplan and Cooper, 1998).

In this study, *Time-driven Activity Based Costing* (Kaplan and Anderson, 2004) was used because it is simpler to use than "traditional" ABC, where the cost object is 2-strip thin walnut wood flooring product (372085VA). Non-value added costs are the sum of cost elements in table 6, where each cost element has its cost driver(s) linked to waste criteria. The unit costs are estimated separately and indicated by table 7.
Table 6. Non-value added costs

<table>
<thead>
<tr>
<th>Cost element</th>
<th>Waste criteria</th>
<th>Cost driver</th>
<th>Estimation</th>
<th>Remarks</th>
</tr>
</thead>
</table>
| Non-conformity costs                 | Imperfection, incorrect      | • Amount of defect                                | \[N_d \times \left\{ (T_M \times C_P) + M \right\}\]                      | \(N_d\): Amount of non-conformity (defects)  
\(T_M\): Machining time  
\(C_P\): Unit cost of added-value processing  
\(M\): Unit cost of material |
|                                     | processing                   | • Machining time                                  |                                                                            |                                                                          |
| Rework costs                         | Imperfection, incorrect      | • Amount of rework                                | \[N_r \times T_M \times C_P\]                                             | \(N_r\): Amount of rework  
\(C_P\): Unit cost of processing |
|                                     | processing                   | • Machining time                                  |                                                                            |                                                                          |
| Failures and stoppages (idles) costs | Incorrect                    | Duration of failures and stoppages                | \((H_F + H_S) \times C_I\)                                               | \(H_F\): Duration of failures while processing the cost object (product)  
\(H_S\): Duration of stoppages while processing the cost object (product)  
\(C_I\): Idle cost per hour |
|                                     | processing                   |                                                   |                                                                            |                                                                          |
| Labour non-value added costs         | Waiting, unnecessary         | Non-value added time                              | \[\bar{v} \times H_L \times S \times N_L\]                               | \(\bar{v}\): Percentage of non-value-added activities  
\(H_L\): Man hours to process the cost object (product)  
\(S\): Hourly wage  
\(N_L\): Number of operators |
|                                     | movements, defects           |                                                   |                                                                            |                                                                          |
| Excess inventory costs               | Unnecessary                  | • Amount of excess inventory                      | \[E \times T_E \times C_E\]                                              | \(E\): Amount of excess inventory  
\(T_E\): Length of holding excess inventory  
\(C_E\): Unit costs of excess inventory |
|                                     | transports, Overproduction,  | • Holding time                                     |                                                                            |                                                                          |
|                                     | Excess inventory             |                                                   |                                                                            |                                                                          |
| Opportunity costs (penalty for tardiness) | Unnecessary                  | • Time                                            | \[(1 - R) \times N_P \times C_G\]                                        | \(R\): Delivery precision  
\(N_P\): Production output  
\(C_G\): Penalty cost per unit due to late delivery |
|                                     | transports, Overproduction,  | • Volume                                           |                                                                            |                                                                          |
|                                     | Excess inventory             |                                                   |                                                                            |                                                                          |
| Opportunity costs (lost)             | Imperfection, Amount of non- |                                                   | \[N_d \times m\]                                                          | \(N_d\): Amount of non-conformity (defects) |
|                                     | defect,                      |                                                   |                                                                            |                                                                          |

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Table 7. Unit cost of non-value added costs

<table>
<thead>
<tr>
<th>Unit cost</th>
<th>Estimation</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
|                            | $C_p = \frac{L_{VA}}{T_p} + \frac{D}{8760} + \frac{W}{T_p}$ | $L_{VA}$: Labour value-added costs  
$T_p$: Number of production hours  
$D$: Machine depreciation (annual)  
$W$: Other overhead costs          |
| Idle                       | $C_I = \frac{D}{8760}$ | $D$: Machine depreciation (annual)                  |
| Excess inventory holding   | $C_E = \frac{M \times y}{365}$ | $C_E$: Inventory holding cost per unit time (day)  
$M$: Material costs  
$y$: Fraction of inventory holding cost [15-35%] |
| Penalty for late delivery  | $C_G = k \times \bar{m}$ | $C_G$: Penalty cost per unit  
k: Estimated percentage of lost profit margin  
$\bar{m}$: Average profit margin |

Step 7: Calculate the added value
The computation of the added-value metric requires measurements of quality, time, and non-value added costs in two different periods. In this study, the first measurement was conducted during May 2006 and the second measurement was conducted during August 2006.

Step 8: Analysis and nomination of improvement projects
The next step is to analyse the metric in order to identify performance gaps using tools such as “the 5 why’s”, which then leads to the nomination of several improvement projects.

Deriving nominated improvement projects from these potential causes is not easy because the nominated improvement projects should be able to address the "real" causes and not just the "symptoms". Therefore, deriving and formulating proactive improvement projects may start from a general
description, which can further be “broken down” into specific descriptions.

Step 9: Project selection
Managers of both primary activities (logistics, operations, marketing and sales, and service) and support activities (e.g. procurement, technology development) along the value chain [as in Porter's model, see e.g. Coyle et al (1996)] were first asked to give their opinion regarding the level of importance of each variable in the benefits and the efforts criteria of project selection before the improvement projects were nominated (using a 1-7 scale, where 1 = very unimportant and 7 = very important). The managers did not receive prior information regarding the nominated improvement projects. Then after improvement projects have been nominated, they were asked again to give their opinion regarding the extent of their agreement whether or not each nominated improvement project has impacts on the project selection criteria. In this case, a 1-7 scale has been used, where 1 = totally disagree and 7 = totally agree.

3.5.3 The quality of the research
My research has largely adapted a qualitative method when it regards theory development (although case study was applied to test theories empirically), which is why the quality of the research will be viewed and discussed according to the criteria of assessing the quality of qualitative research, i.e. trustworthiness, which is made up of four criteria: credibility, transferability, dependability, and confirmability (Guba and Lincoln, 1994).

Credibility
Credibility (parallels internal validity) is about the believability of the findings, through respondent (or member) validation (i.e. submitting the research findings to the members of social world) or triangulation, i.e. a method that entails the use of more than one method or source of data in the study of social phenomena (Bryman, 2004), i.e. multiple observers, theoretical perspectives, sources of data, and methodologies (Denzin, 1970).

The credibility of my research is best reflected by triangulation, although respondent (member) validity can also be used to demonstrate the validity
of the research. Triangulation has been applied in the sense that I used more than one method or source of data (i.e. qualitative method and case study) as well as that I used theoretical perspectives. I have applied respondent validation in my research because the results of both studies have been presented to the respondent (in this case the case company).

The results of the first study have previously been presented to the board of directors, where the CEO himself confirmed the relevance of the findings and the suggestions. A similar confirmation came also from the quality manager at that time.

The results of the second study have been presented to three groups of audience in the case company, i.e. board of directors, quality management [quality manager and staff], and production management [manager and staff of final processing; production planner]. Based on the discussions with these groups, it seems that:

- The added value measurement is able to indicate the areas or activities in the company that have performance gaps or that are ineffective, as well as to show the effects of waste or the severity of waste’s consequences.
- The nominated improvement projects "articulates" their "voices" regarding what could be done in order to improve the company's competitive advantage. In particular, the board of directors and the quality management group showed interest on the "supplier quality assurance" project, while the production management group indicates the necessity of the "productive customer response" project.

Transferability

Transferability (parallels external validity) provides explanations regarding the applicability of the findings to other contexts (Bryman, 2004), which can be done by providing more details about the setting (Hoepfl, 1997) and/or locating one’s research within an explicit conceptual and theoretical frame (Bailey, 2007).

Based on the above description, the transferability of my research has been described through my research framework and research structure, as well as the context of empirical studies.
Dependability

*Dependability*, which parallels reliability, asks the question whether the findings are likely to apply at other times (Bryman, 2004). In qualitative research, the results will not be exactly the same when conducted at other times. However, the dependability of qualitative research can be enhanced through providing the details of the research process that shows correspondence between the methodology and the conclusions (Bailey, 2007).

I demonstrated the dependability of my research by describing the details of the research process and the way I planned the case studies.

Confirmability

*Confirmability* (parallels objectivity) is related to the issue whether the researcher has overtly allowed his/her values to influence the research and findings derived from it (Bryman, 2004; Bailey, 2007). When working under the standard of confirmability, the researcher does not have to engage in the pretence of objectivity, but clearly articulates and embraces the role that values play in the research process (Bailey, 2007).

Based on the above description, it will be impossible to be completely objective in this research. However, I believe this research has a high level of confirmability because: 1) the analysis and interpretation has been anchored to the existing theories, 2) two senior quality staff in the case company have been involved in the case studies by providing advices during the data collection process (planning and execution) as well as that they were to whom I discussed the results with.

The quality of the research viewed from the system approach

Taking the perspective of system approach, I have validated my research by studying customer value from different angles (e.g. in the fields of marketing, quality management, and service) and by studying as much as possible literature from these fields, as well as by “staying” in a “real” system (the case company) for approximately two years, where I have talked to various persons in the case company at different levels and positions. Considering the way system approach views generalisation and reliability, these aspects are not discussed further.
3.6 The case company

3.6.1 General facts
The case company is a Swedish wood-flooring manufacturer, founded in 1857. It is one of Europe's leading parquet- and wood-flooring producers, which mainly serves US and European markets. The main customers of the company's products are builders, merchants, and retailers. Meanwhile, the majority of end users are private people. The company's vision is "to be recognized as the leading brand and trade partner in multi-layer wood flooring".

Today the company is an international company selling 80 percent of its products to more than 40 different markets, with sales revenue more than 200 million Euros per year during 2003-2005. With number of employees more than 1500 (average during 2003-2005), the company operates four production units in Scandinavia, while some production of wood-flooring is outsourced to companies in Europe.

3.6.2 Wood-flooring products
The wood flooring produced by the company has a three-ply structure, which is available in different thicknesses. It is offered in one-, two-, or three-strip variants (there is also a special pattern called Holland-pattern). Depending on the appearance (character) of the wood flooring boards, each one of these variants is further available in three different classes called Style, Life, and Classic. These products are basically similar in terms of production processes and engineering design. The main difference is on the appearance, which is the combination of wood structure, wood species, and finishing materials. In total, the company presents the consumers with hundreds of flooring combinations to select from. The products are equipped with the innovative, glue free, joint system called Woodloc.

The wooden floors produced by the company are thick wood flooring products (15 mm, where the wearing surface is about 3.6 mm thick) and thin wood flooring products (7 mm, where the thickness of the wearing surface is only about 0.6 mm). Besides these two products, there are other products adding up to a smaller portion of the total production volume: parquet flooring 20 mm and ship flooring (skeppsgolv, a special wood
floors consisting of special form of edges). Regardless of the thickness of the product, the floors consist of wearing surface and frame (as shown by figure 7). The major difference between thick wood flooring products and thin wood flooring products is the middle layer. The middle layer for thick wood flooring consists of glue-joined wooden “sticks” and veneer, while the middle layer of thin wood flooring is a high-density fibreboard (HDF) and veneer.

Figure 7. Structure of wood flooring products

3.6.3 Production process of wood-flooring

Wood flooring production (figure 8) in general can be classified into three phases: production of the components, joining, and final processing. The components of wood flooring products are the wearing surface and the frame (the production process of these components will be described later). The joining process consists of gluing and pressing. Final processing includes surface treatment and profiling. Surface treatment is a group of processes: sanding, filling (spackle), and varnishing/lacquering. Profiling is a process to enable glue-less flooring installation. In the case company, there are two final processing lines: one for 15 mm products and one for 7 mm products. The final processing line for the 15 mm products consist of the following processing machines or functions: sanding, filling, and polishing. The final processing line for the 7 mm products is performed by one machine, which integrates the sanding, filling, and
polishing functions. Sometimes this machine is also used for processing the 15 mm products that has special finishing requirements (e.g. using UV-oil). The wood floor products are finally inspected and packaged.

Figure 8. Process flow of wood flooring production

The raw materials for wood-flooring products are mostly supplied as WIP to the factory although the factory also produces its own. The term WIP here is defined as wood flooring products, which have been joined (glued and pressed, sometimes filled) but not yet surface treated and profiled.

The production of wearing surface (figure 9) begins with the cutting of sawn timber into different lengths (e.g. 202 mm, 270 mm, and 347 mm) with the help of cameras in order to optimise the output. These woods are then sliced into wood panels and sorted in order to determine whether it can be used to produce first grade or second grade wood floors. The sorting activities are performed both manually and by using a scanning device called "wood eye" (mostly for tougher wood flooring specifications including specific appearance from the market). The sorting operators also decide whether a panel will be used to create a first grade or a second grade product. A wearing-surface board consists of several wood panels depending on the dimensions of the panel and the pattern creation. After deciding the pattern of the wearing surface, the wooden panels are side-glued.
The production of the frames (figure 10) starts with cutting the board (dried spruce/pine), then sawing the wood into several wooden *sticks*. These wooden sticks are then sorted in order to separate the damaged or defect pieces. The next step is to glue these wooden sticks with a back veneer (usually spruce or pine) before warm pressing. Then, the pieces are aligned in order to cut the wooden sticks that stroked out exceeding the back veneer. The joining parts are then cut into two equally wide parts; each part is the frame of wood flooring. These frames are inspected before joined with wearing surface.
4. The foundation for the development of quality management toward customer value creation

4.1 The pathway to value creation

As reviewed in the theoretical review chapter, what is being perceived as valuable by customers is not just the ability of products or services to fulfil goals or needs, or if the products or services give value for money. The customers also include judgment on suppliers’ (producers’) performance and their knowledge about customers.

Thus, producers need to convince the customers that they adequately understand what the customers do value and demonstrate their performance in creating/delivering customer value. Mele and Colurcio (2006) suggest that in order to optimise customer value, firms need to do the following actions: improve focus on customer needs, measure customer value, strengthen customer relationship, creative thinking on every aspects of business activities, and develop value innovations.

Figure 11 describes the pathway of value creation through quality management. The pathway starts with awareness and understanding the implications of customer value on the supply side, that the relationship between customer value and quality is bi-directional, in the sense that customer value is not only about what “comes out” but also what is “brought in” (Evans, 2002). This awareness and understanding lead to a profound knowledge of customer value, which becomes a guideline of how an organisation may create customer value through quality management. The next step is to further develop operative quality management into value-oriented quality management in order to support the strategic aim of quality management.
4.2 The Profound Knowledge of Customer Value

According to Linderman et al (2004), knowledge plays a critical role in the development of quality management and in understanding organisational improvement activities (p. 590). Mele and Colurcio (2006) imply that the creation of customer value requires organisations to take actions (p. 484), i.e. being “active”. Thus, developing quality management as a value-creation method requires principles that guide the development.

The awareness and understanding of the impact of customer value on the supply side creates a “new mindset” of how producers should view customer value in order to identify what customers consider as valuable, and also knowing its role as the creators of customer value. These two points are the “essence” of the Profound Knowledge of Customer Value.
(PKCV), which contains four principles. Each principle of PKCV is to be explained in the following sub-sections.

4.2.1 Principle 1: Appreciation for a value creating system

A firm (company) is a value-creating system that generates customer value based on producer’s understanding of what the customers do value. Hence, customer value is both the input and output of a value-creating system.

It has been discussed in the theory chapter (chapter 2) that customer value is about what “comes out” (output) and what is “brought in” (input). Customer value as an output is related with customers’ perceptions (states of mind), which thus indicates producers’ performance. Perceived customer value and received customer value are the manifestation of customer value as an output. The producers analyse (and interpret) value-related performance measurements, which are useful (as inputs) to identify improvement opportunities. The producers’ efforts to improve quality may in turn affect customer value.

Customer value as an input and output explain the interaction (interrelationship) among different definitions of customer value in different contexts. This interaction can well be described by system thinking (Senge, 1990), through an inner loop and an outer loop (see figure 12).

The inner loop
The inner loop starts with perceived customer value (in a purchase-context), which may be seen by producers through exchange value. The higher exchange value, the higher is perceived customer value (seen by the producer). A model that is derived from exchange value leads to an understanding that quality improvements (QI) affect customer perceived value (paper II), under the circumstance that the selection and evaluation of quality improvement projects should be value-oriented and thus be redefined in terms of a “trade-off” between benefits (for the organisation and customers) and efforts (of the organisation). This perspective of viewing quality improvements influence the way we nominate and select improvement projects, where a project can be reactive or proactive.
Proactive improvement projects should be selected based on the *perceived added value*, i.e. the ratio between overall perceived benefits (for the organisation and customers) and overall perceived efforts of improvement projects (for the organisation). Reactive improvement projects are perceived (by the producer) as adding value (to customers) if the projects are related to customer requirements or support business strategy (i.e. related to company’s main product portfolio). In the inner loop, the identification of *waste* along the value stream is a source of quality improvement opportunities. Another source for improvement opportunities is through the identification of quality attributes (using value-driven P-I matrix) that cause low *perceived customer value*. From a process perspective, improving quality by reducing/eliminating waste will add value to customers. Thus *added value* becomes a lead-indicator for how quality improvements might improve the way customers perceive the value of the product.

![Figure 12. Customer value as input and output of a value creating system](image)
The outer loop
Exploring *received customer value* (in the use context) will enable producers to identify the value that are found critical by customers, leading to an understanding about the critical *value components* (product attributes that are “responsible” for creating critical value). These value components are important for developing new products or improving the design of existing products.

The outer loop also concerns with the identification of value components that are critical to competition (by exploring *perceived customer value*), meaning that product attributes that cause a low perception of value (relative to competitors) are improvement opportunities. Nominated improvement projects are then selected based on *perceived added value*.

4.2.2 Principle 2: Knowledge about customer value “modes”

There is variation in defining what customer value is because customer value involves both supply and demand systems. Therefore, it is important to recognise different “modes” of customer value, meaning that the definition of customer value varies for each individual and in different situations, as well as that the definition varies for producer as for customers.

In order to enable the producer to take active roles in value creation, customer value needs to be put in an operational term (through its lower level of abstraction), yet without disconnecting it to the higher level of abstraction. To achieve this purpose, it is important to view that [in different contexts] customer value operates in different “modes” (see the concept of *Value Modes Effect and Analysis* in paper I). These value “modes” (figure 13) facilitates producers in the value creation process by providing different operational definitions of customer value.

![Figure 13. The Value Modes](image-url)
4.2.3 Principle 3: Theory of Improvements

Customers’ perception about the value of a product can be influenced by improving quality, which is carried out as projects that add value to customers. These projects can be categorised into proactive and reactive projects, in addition to big Q (within business processes) and little Q categorisation (within production processes).

It has been described in paper II that the dynamics of perceived customer value (measured as a ratio between perceived customer value at two different periods) is equal to the ratio between exchange value at period (i+1) and i, in which exchange value is a ratio between utility and price.

Since utility is a function of quality, the changes in quality thus influence the dynamic of utility. Meanwhile, as price is a function of costs, the changes in costs will influence the dynamic of price. Costs can be defined as a sum between value-added costs and non value-added costs. Consequently, the changes in quality will also influence the changes in price due to the impacts of the changes in quality on the non value-added costs. Hence, quality improvements will affect the dynamics of exchange value and thus the perceived customer value. This became a motivation to assess the efforts to improve quality from a value perspective, i.e. the value of quality improvements (paper II) instead of just viewing quality improvements from a cost-perspective based on quality costs.

Paper IV argues that quality improvements should embrace both reactive and proactive improvement projects in the production processes (little Q) as well as within the business processes (big Q). These projects should be selected based on perceived added value, i.e. the potential contribution of a project in adding value to customers, which is defined as a ratio between perceived benefits (for the organisation and customers) and perceived efforts of the organisation when conducting the project.

4.2.4 Principle 4: Perception

If the producer knows and understand what the customer needs and wants (value), then the producer will be motivated
to fulfil customers’ needs. The producer may eventually gain rewards, such as customer loyalty and shareholder value.

A “modified” Grönroos’ (1997) conceptual model of customer value can be used to explain the “overall” concept of customer value from producers’ view. Thus customer value can be expressed as:

\[ CV = CCV \pm ACV \]  \hspace{1cm} (4)

Where:
CV : Customer value
CCV : Core customer value
ACV : Added customer value

Core customer value is the value derived from the consequences of using/consuming products or services [created by producers or service providers] to fulfil customer goals or needs. Meanwhile, added customer value is the additional value derived from the process of creating/delivering core customer value, or additional services [augmented products] provided by producers in addition to the main products. Thus, core customer value reflects suppliers’ competence in terms of output (products), while added customer value reflects suppliers’ competence from a process perspective. It is expected that added customer value would have a positive effect on core customer value, meaning that added value leads to customers’ confidence in their choice (de Chernatony et al, 2000), although added value may also have a negative effect (Grönroos, 1997), e.g. online purchasing adds value to customers through its convenience. However, this value added may have a negative effect, in the sense that when there is an error in the online purchasing process, it may require greater efforts to fix (than regular sales) and causes more irritation for the customer.

Consequently, customer value reflects the producer’s value creation potential, where core customer value is:

- A trade-off between the benefits for customers as the contribution of the supplier’s competencies and the sacrifices to acquire these competencies, or
• The ratio between customers’ willingness to pay for the competencies and the producers’ estimated selling price.

Meanwhile, added customer value can, from the producer’s point of view, be defined as the ratio between the benefits of improving the competencies of core value creation/delivery and the change in costs that may occur due to improving the competencies.

4.3 Comparison with the System of Profound Knowledge

PKCV is an approach to understand how and to whom the system is creating value for, which can be seen as a re-interpretation of Deming’s (1994) System of Profound Knowledge (SPK) in order to understand a system. Thus, the importance of PKCV can be explained through its role as guiding principles that enable organisations to gain customer-related knowledge and to take necessary actions in order to create, deliver, and optimise customer value through quality management. Table 8 provides a comparison between PKCV and SPK.

The PKCV may be useful when exploring the concept of “transformative quality” (in Harvey and Green, 1993) which includes cognitive transcendence (and not just physical transformation), meaning that quality should be explored in terms of a wide range of factors leading to a notion of “value addedness” (Müller and Funnell, 1992; in Dahlgaard et al, 1998). The transformative quality concept is relevant for customer value oriented quality management due to: 1) the discussion about value "modes" in the PKCV provides a sensible description about the changes of "form" (analogue to the transformation of physical forms of water in different temperatures), where value (as well as quality) is a physical (tangible) matter in a certain context but is a cognitive (emotional) matter (intangible) in another context, and 2) the suppliers’ empowerment, meaning that suppliers are able to influence customer value, which changes the view regarding suppliers’ roles in the customer value creation, from “passive” (in the customer-centric view of customer value) to “active” (in the competence-related view of customer value). The changing roles of suppliers re-emphasises the necessity of creativity and cross-functionality in managing quality in organisations.
Table 8. The Profound Knowledge of Customer Value versus Deming’s System of Profound Knowledge

<table>
<thead>
<tr>
<th>The System of Profound Knowledge</th>
<th>The Profound Knowledge of Customer Value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Appreciation for a system</strong></td>
<td><strong>Appreciation for a value-creating system</strong></td>
</tr>
<tr>
<td>An organisation/company is a system of interdependent components to achieve a certain aim/goal.</td>
<td>A company is a system of interdependent components to create (add) value. The value created in different stages (contexts) is interdependent.</td>
</tr>
<tr>
<td><strong>Knowledge about variation</strong></td>
<td><strong>Knowledge about customer value modes</strong></td>
</tr>
<tr>
<td>There is variation between people, in output, in service, in product.</td>
<td>There is variation in customer value definitions.</td>
</tr>
<tr>
<td><strong>Theory of knowledge</strong></td>
<td><strong>Theory of Improvements</strong></td>
</tr>
<tr>
<td>Systematic revision and extension of theory (in order to manage and build knowledge about the system) follow a PDCA mechanism.</td>
<td>Systematic way of improving quality (in order to create/add value) follows reactive and proactive roadmaps.</td>
</tr>
<tr>
<td><strong>Psychology</strong></td>
<td><strong>Perception</strong></td>
</tr>
<tr>
<td>Understanding the uniqueness of people and the way they interact with the surroundings in order to motivate them and identify the right way of giving appreciation (reward).</td>
<td>Understanding the uniqueness of customers and their needs/wants is a way of giving appreciation to customers and will motivate producers to fulfil those needs. Understanding customers may lead to reward such as customer loyalty and shareholder value.</td>
</tr>
</tbody>
</table>
5. The development of forward-looking quality management toward customer value creation

Developing forward-looking quality management toward customer value creation is the result of reflections on papers I and V, where the process of developing forward-looking quality management toward customer value creation can be described by the principles of the Six Sigma methodology (see e.g. Andersson et al 2006): define the process or product that needs improvement, measure key factors that have the most influence on the process, analyse the factors that need improvements, improve by designing and implementing the most effective solution, and control by ensuring that the improvement sustains over time.

It may not be difficult to notice that the above Six Sigma principles are indirectly (if not at all) linked to customer value. However, after reinterpretation (as shown in table 9), those principles can be used to describe the development of forward-looking quality management toward customer value creation.

Table 9. Re-interpretation of Six Sigma methodology

<table>
<thead>
<tr>
<th>Principle</th>
<th>Re-interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>Define customer value</td>
</tr>
<tr>
<td>Measure</td>
<td>Measure customer value</td>
</tr>
<tr>
<td>Analyse</td>
<td>Analyse customer value</td>
</tr>
<tr>
<td>Improve</td>
<td>Identify, select, and implement forward-looking quality improvement opportunities</td>
</tr>
<tr>
<td>Control</td>
<td>Evaluate the capability to provide fair and/or high customer value through continuous measurements of customer value</td>
</tr>
</tbody>
</table>

With consideration on the research focus, this chapter contains conceptual descriptions, which are important for the further development of forward-looking quality management.
5.1 Define
The suppliers (producers) should define value according to customers’ perceptions in the context of purchase and use. Customer value in a purchase-context is known as \textit{perceived customer value}, while customer value in a use-context is known as \textit{received customer value}. Both perceived and received customer value can be explained by a utilitarian model, meaning that customer value is a trade-off between customers’ perception of benefits and sacrifices.

5.2 Measure
Due to the fact that the concept of customer value is dependent on its context, then the way of measuring customer value is different in various contexts. Consequently, measuring customer value should distinguish between the measurement of \textit{perceived customer value} and \textit{received customer value}.

5.2.1 Measuring perceived customer value
Zeithaml (1988) and Lin et al (2005) are among the researchers who suggest that customer perceived value is the ratio between perceived benefits and perceived sacrifices. Gale (1994) transforms this definition into a performance measurement by defining customer perceived value as the ratio between \textit{Market Perceived Quality} (MPQ) and \textit{Market Perceived Price} (MPP). Thus, in the purchasing context, perceived customer value (PCV) can be defined as:

\[
PCV = \frac{MPQ}{MPP} = \frac{\sum_{i=1}^{n} w_i * R_i}{\sum_{j=1}^{m} w_j * R_j}
\]

(5)

Where:
\(w_i\) : Importance weight of quality attribute \(i\) \((i = 1, 2, \ldots, n)\)
\(w_j\) : Importance weight of price attribute \(j\) \((j = 1, 2, \ldots, m)\)
\(R_i\) : Product A’s performance score on quality attribute \(i\) relative to competing products
\(R_j\) : Product A’s performance score on price attribute \(j\) relative to competing products.
\( n = \text{Number of quality attributes} \)
\( m = \text{Number of price attributes} \)

Gale’s (1994) work has become inspiration to further explore customer value as a performance measure. In paper I, the concept of perceived customer value is “extended” by accommodating *Life Cycle Costs* (LCC). Perceived customer value is re-defined as a ratio between *Customers’ Cognitive Judgment on Quality* (CCJQ) and *Customers’ Cognitive Judgment on [life cycle] Costs* (CCJC).

\[
PCV = \frac{CCJQ}{CCJC} = \frac{\sum_{i=1}^{n} w_i * R_i}{\sum_{j=1}^{m} w_j * R_j}
\]  

(6)

Where:
\( w_i \): Importance weight of quality attribute \( i \)
\( w_j \): Importance weight of cost attribute \( j \)
\( R_i \): Product x’s performance score on quality attribute \( i \) relative to competing product
\( R_j \): Product x’s performance score on cost attribute \( j \) relative to competing product

This type of customer value measures customer value of a product (or a firm) relative to its competitors. Paper I provides an example that describes the measurement of perceived customer value.

### 5.2.2 Measuring received customer value

Paper V describes that taking into account customers’ individual voices when using a particular product (not in comparison with other products) – in the context of non-competition, is necessary for creating customer value that has long-term effects (sustainable). It is suggested in this paper that received customer value should be measured over time.

Basically, the trade-off model can still be used in order to measure received customer value. However, the term “benefits” here implies on the product benefits that customers value when using the product.
Means-end theory/model, see e.g. Hermann and Huber (2000) and Reynolds and Olson (2001), suggests that when a product is in use, product attributes lead to (expected/wanted) consequences, which enable the customers to achieve their values (i.e. goals, needs, personal values).

It has been argued that a compromised definition of customer value is needed in order to avoid or reduce the risk for value paradox, i.e. that producer and customers define customer value in different ways. Therefore, it is suggested (paper V) that functional utilities should be used as the compromised definition of values when identifying the “benefits” of the product in a use-context. Functional utilities, which refer to the usefulness or the outcomes as the consequences of using a product, are perceived by the customers but still can be influenced by the producers. Consequently, producer and customers will likely have a common definition and view value in the same way.

Hence, received customer value is defined as:

\[
RCV_i = \frac{U_i}{C_i} = \frac{\sum_{j=1}^{m} w_j * u_j}{\sum_{h=1}^{g} w_h * c_h}
\]  

(7)

Where:
RCV \_i : Customer value perception of customer i  
U \_i : Cognitive judgment of customer i on the product’s functional utilities  
C \_i : Cognitive judgment of customer i on the product’s life cycle costs  
w \_j : Importance weight of functional utility j  
w \_h : Importance weight of cost component h  
u \_j : Functional utility j  
c \_h : Component h of life cycle costing  
j: 1, 2, … m  
h: 1, 2, … g
Issues concerning implementation
The applicability of the PCV and RCV metrics has been demonstrated numerically by using illustrative examples and computer simulation (in paper I and V) although only fictive variables have been used. Operating definition of these variables is required when the PCV and RCV metrics are to be applied empirically.

When measuring PCV, the “benefits” will be represented by quality attributes, while functional utilities (which are identified by using means-end model) represent the “benefits” when measuring RCV. Table 10 provides examples of defining quality attributes and functional utilities of wood flooring.

Table 10. Examples of quality attributes and functional utilities of wood flooring

<table>
<thead>
<tr>
<th>Attributes</th>
<th>Functional utilities†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensional precision</td>
<td></td>
</tr>
<tr>
<td>Moisture adaptability</td>
<td></td>
</tr>
<tr>
<td>Uniform gloss</td>
<td></td>
</tr>
<tr>
<td>Colour combination</td>
<td></td>
</tr>
<tr>
<td>Free from cracks</td>
<td></td>
</tr>
<tr>
<td>Easy cleaning *)</td>
<td></td>
</tr>
<tr>
<td>Not getting filthy easily *)</td>
<td></td>
</tr>
<tr>
<td>Sound absorbing *)</td>
<td></td>
</tr>
<tr>
<td>Natural material *)</td>
<td></td>
</tr>
<tr>
<td>Warmth *)</td>
<td></td>
</tr>
<tr>
<td>Wood feeling *)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hygiene *)</td>
</tr>
<tr>
<td></td>
<td>Nice atmosphere *)</td>
</tr>
<tr>
<td></td>
<td>Nice underfoot *)</td>
</tr>
</tbody>
</table>

*) from Johnsson (2005)

An example of defining the components of life cycle cost (LCC) can be found in Moussatche and Languell (2001), where the LCC is the net present worth of capital cost, replacement cost, and maintenance cost. Each of these costs can potentially be broken down into smaller components (table 11).

† The functional utilities in this table are hypothetical. They need to be confirmed (or disconfirmed) using hierarchical value map.
Table 11. Life cycle cost (LCC) of wood flooring

<table>
<thead>
<tr>
<th>LCC components</th>
<th>Cost breakdown</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital cost</td>
<td>• Product price</td>
</tr>
<tr>
<td></td>
<td>• Installation cost (supplies + labour†)</td>
</tr>
<tr>
<td>Replacement cost</td>
<td>• Product price</td>
</tr>
<tr>
<td></td>
<td>• Installation cost (supplies + labour)</td>
</tr>
<tr>
<td>Maintenance cost</td>
<td>• Re-sanding cost (supplies + labour)</td>
</tr>
<tr>
<td></td>
<td>• Refinishing cost (supplies + labour)</td>
</tr>
</tbody>
</table>

Although the denominator of the PCV and RCV metrics focuses only on cost-related elements, it is necessary to be aware that the “sacrifices” in the customer value equation may also include non-monetary elements. In case of wood flooring, these non-monetary sacrifices may stem from the fact that the product: is not moisture-friendly, could be dangerous due to chemical emissions, and is not “immune” towards fire hazard, fungi, or wood ticks.

5.3 Analyse

5.3.1 Analysing perceived customer value

The purpose of analysing perceived customer value measurements is to find out: 1) if a product is perceived as having fair, high, or low value and 2) if a product is perceived as providing more value than the competitor(s). Analysing perceived customer value involves studying the perception of both own and competitors’ customers.

The concept of fair value varies across customers depending on their background. Hence, it may be difficult to know the “exact” limits of fair value (i.e. the zone of fairness). However, the producer may estimate these limits by simply defining that a product provides a fair value if the calculated customer value is within three (or another number) standard deviations from the average customer value. The customer perceives that the product provides a significantly higher value if the calculated value

† Labour-related cost component is not applicable in case of "Do it Yourself" (DIY)
exceeds the upper limit of fairness zone, and if the calculated value is below the lower limit of fairness zone then the value of the product is perceived as significantly lower than the average value. Each of these conditions is actually “special variation” due to “special causes”. Therefore the producer may need to take actions to bring the measurements within control limits. In case that the calculated value is above the upper control limit, the producer may charge additional costs on the product, service, or transaction through strategic pricing, while in case that the calculated customer value is below the lower control limit, the producer should improve the quality-related attributes where the performance score is significantly lower than the importance (see paper I). Thus, the producer’s actions to “control” the “special causes” of variation in the calculation of customer value make customers’ perceptions regarding the product’s value dynamic. This implies the necessity of “monitoring” customer value over time, which has not yet been discussed in Gale’s (1994) Value Mapping. Section 5.5 discusses this issue although customer value monitoring is discussed in a non-competition context.

Customers perceive that a product provides more value than its “competitor(s)” if the product provides more benefits than “competitor(s)” at the same level of cost, or if the product costs less than the “competitor(s)” at the same level of benefits. These are the situations where the producer gains competitive advantage in the market.

5.3.2 Analysing received customer value

The purpose of analysing the measurements of received customer value is to find out to what extent a company’s own customers perceive the value of a product as fair, low, or high. The value-based segmentation enables the producer to identify product attributes that are critical to different segments. This can be achieved by segmenting the customers into three different clusters, which represent three “areas” in customer value mapping (i.e. fair-value, high-value, and low-value), based on their cognitive judgment on the product’s functional utility (U) and life cycle costs (C). Customers that have similar judgments are classified in the same cluster. The value-based segmentation can be done using, e.g. *K-means clustering*, with the help of statistical software such as SPSS. If the demographic variables of the customers were recorded, the “profile” of
each segment can be identified by testing whether the cluster number is associated or not with a certain demographic variable.

It is difficult to determine the exact limits of fair value (zone of fairness) because the notion of fair value varies across customers depending on their background or characteristics. Therefore, the producer may estimate the zone of fairness by defining that the zone of fairness is within three (or another number) standard deviations from the average customer value.

Above the upper control limit, customers perceive the product’s value as high, which may indicate that either 1) the product fits the customers’ use situation or 2) the product is not perceived as costly. Hence, the producer can utilise this knowledge for marketing purposes. Customer value measurements above the upper control limit is variation due to “special causes”. Therefore, the producer may take actions in order to “pull down” the customer value measurement points inside the control limits through strategic pricing (in different segments) or by charging extra costs for augmented products or additional services.

Any measurements below the lower control limit indicate low perception of value, which may indicate that either: 1) the product does not fit the customers’ use situation (due to producer’s poor understanding of use situation or customer’s own mistake) or 2) the product is perceived as costly. Customer value measurements below the lower control limit is variation due to “special causes”. Thus the producer should take action in order to “elevate up” the customer value measurements inside the control limits by: 1) ensuring that customers know the proper use of the product, 2) improving the design/specification of the product to better suit customers’ use situations, 3) improve process and operational performance, or 4) offering additional services without charging extra costs in order to reduce customers’ sensitivity on the costs.

Thus, the producer’s actions towards “special causes” of variation in the customer value measurements will influence the dynamics of customers’ perceptions regarding the value of the product. Therefore, it is necessary to “monitor” customer value over time (to be described in section 5.5).
5.4 Improve

Analysing customer value measurements will eventually lead to the identification of improvement opportunities and thus project nomination and selection.

5.4.1 Project nomination

Based on perceived customer value

In paper I, the author suggests that the producers (with the help of the performance-importance matrix or PI matrix) can find improvement opportunities (i.e. identification of quality attributes that cause low perception of value in comparison with competitors. A quality attribute \( j \) should be improved if the difference (\( D \)) between the average performance score and the average importance score is less than minus three standard deviations (-3s). Thus:

\[
D_j < -3s
\]  

(8)

Or

\[
\left( \overline{P_j} - \overline{I_j} \right) + 3 \sqrt{\frac{\sum_{j=1}^{m} (P_j - I_j)^2}{n^* (m-1)}} < 0
\]

(9)

Where:

- \( \overline{P_j} \): The average performance score of quality attribute \( j \) of \( n \) customers
- \( \overline{I_j} \): The average importance score of quality attribute \( j \) of \( n \) customers
- \( n \): Number of customers
- \( m \): Number of quality attributes

The application of this principle is available in paper I.

Based on received customer value

Identifying the values (functional utilities) that are critical-for-customers using the algorithm in paper V may lead to identification of improvement opportunities, in the sense that producers will be able to determine and continuously improve the quality attributes that, according to the means-
end model, have impact on the critical values. A value (functional utility) is considered as critical by a certain segment if the priority rate of this value is equal or greater than its overall priority rate (by all segments). This reasoning can be expressed as:

$$PR_{j\_segment} \geq PR_{j\_overall}$$  \hspace{1cm} (10)

Where:
- $PR_{j\_segment}$: the priority rate of functional utility $j$ in a segment
- $PR_{j\_overall}$: the overall priority rate of functional utility $j$

Priority rate is, in general, defined as a ratio between the importance score of a functional utility ($I_j$) and the maximum importance score of all functional utilities ($I_{max}$). Thus:

$$\frac{I_{j\_segment}}{I_{max\_segment}} \geq \frac{I_{j\_overall}}{I_{max\_overall}}$$  \hspace{1cm} (11)

Where:
- $I_{j\_segment}$: Average importance score of functional utility $i$ in a segment
- $I_{max\_segment}$: Maximum importance score of functional utilities in a segment
- $I_{j\_overall}$: Overall importance score of functional utility $i$
- $I_{max\_overall}$: Maximum importance score of overall functional utilities

The application of the algorithm can be seen in paper V.

5.4.2 Project selection

After the improvement projects have been nominated, the next step is to select the improvement project to work with. Perceived added value (in paper IV) is a method to select improvement projects where the selected project is perceived as having the largest potential of adding value to customers. Perceived added value (PAV) is defined as:
\[
P_{AV} = \frac{\text{OPB}}{\text{OPE}} = \frac{\sum_{i=1}^{n} w_i \times PB_i}{\sum_{j=1}^{m} w_j \times PE_j}
\]  

(12)

Where:
- **OPB**: Overall Perceived Benefits
- **OPE**: Overall Perceived Efforts
- \(w_i\): Importance weight of benefit \(i\)
- \(w_j\): Importance weight of effort \(j\)
- \(PB_i\): Perception score of benefit \(i\)
- \(PE_j\): Perception score of effort \(j\)

To gain comparable PAV results regardless measurement scales used (e.g. whether a 1-7 or a 1-10 scale) the above equation can be *normalised* by first subtracting \(PB_i\) or \(PE_j\) with the lowest score in the measurement scale, i.e. one (1), and then divide the result with the range of the measurement scale (see paper IV for further description of this procedure).

Selecting proactive improvement projects requires us to determine which aspects should be included in Overall Perceived Benefits (OPB) and Overall Perceived Efforts (OPE) as well as the relative importance of each aspect. The following description provides a review of the common criteria used for selecting Six Sigma improvement projects and then “reorganise” these criteria to define the components of OPB and OPE.

**The structure of Six Sigma project selection aspects**

In Six Sigma project selection, the project selection aspects used are very diverse because different researchers tend to define and use their own terminologies, as well as the variation regarding the number of aspects considered in a project selection process. After having reviewed some lead articles in Six Sigma, it is concluded that: 1) there is very little awareness that project selection aspects construct a hierarchical structure, and 2) there is no discussion regarding which level that should be considered in the project selection process, and what the implications are.
Pande et al (2000; in Antony and Banuelas, 2002) provide three generic criteria of project selection: business benefits criteria, organisational impact criteria, and feasibility criteria, where each criterion could be "specified" into several sub-criteria (see table 12). These sub-criteria are also those, which are suggested by Kwak and Anbari (2006) when selecting Six Sigma projects. Antony et al (2004) describe that Six Sigma projects have impacts on customers, financial, organisational performance, etc, and these potential impacts are also the reasons of implementing Six Sigma. It can be argued that these impacts belong to the sub-criteria. Anthony et al (2004) further describe that the impacts can be "specified" into several "variables" (see the detail in table 13). Thus, the aspects to assess improvement projects actually are constructed into the following hierarchy: criteria, sub-criteria, and variables.

Table 12. Criteria and sub-criteria of project selection aspects

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Business benefits</td>
<td>Impact on meeting external customer requirement</td>
<td>Customer-oriented</td>
<td>Impact on customers</td>
</tr>
<tr>
<td>Financial impact</td>
<td>Financial benefits</td>
<td></td>
<td>Financial impact</td>
</tr>
<tr>
<td>Impact on core competencies</td>
<td></td>
<td></td>
<td>Impact on process; impact on organizational performance</td>
</tr>
<tr>
<td>Organisational impact</td>
<td>Cross functional</td>
<td>Organisational benefits</td>
<td></td>
</tr>
<tr>
<td>Learning benefits</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feasibility</td>
<td>Resources required</td>
<td>Feasible</td>
<td>Impact on project</td>
</tr>
<tr>
<td></td>
<td>Complexity</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Expertise availability</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The hierarchical classification above was then crosschecked with other project selection aspects suggested by the other researchers in table 13.

Table 13. Project selection aspects used by other researchers

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Project selection aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antony et al (2004): reasons to implement six sigma</td>
<td>COPQ; quality &amp; waste; inventory; productivity; process yield; reduced variability; customer satisfaction; market share; higher fulfilment of customer requirement; business strategic goals; cost/benefit; resource and budget; risk; time to complete project</td>
</tr>
<tr>
<td>Banuelas Coronado and Antony (2002)</td>
<td>Quality; delivery time; reliability; cost; customer satisfaction; business profitability; process cycle time; throughput yield</td>
</tr>
<tr>
<td>Bacdayan (2001)– success factors when selecting improvement projects</td>
<td>Significant for customers (and therefore for top management); manageable scope and resources (including project team); focused on work process (that is able to define or describe)</td>
</tr>
<tr>
<td>Harry and Schroeder (2000)</td>
<td>Customer satisfaction; net cost saving; cost of poor quality (COPQ); internal performance; DPMO; capacity; cycle time</td>
</tr>
<tr>
<td>Pyzdek (2003)</td>
<td>Sponsorship (<em>top management commitment</em>); benefits to stakeholders (i.e. customer satisfaction, financial, reduced cycle time, revenue enhancement, employee satisfaction); resources availability; scope (<em>likelihood to deliver success</em>); deliverable (<em>clarity of expected project output</em>); time to complete; team membership (<em>readiness and commitment</em>); project charter (<em>clarity of project definition/formulation</em>); value of six sigma approach (<em>significance of six sigma</em>)</td>
</tr>
<tr>
<td>Snee and Rodebaugh Jr (2002)– Six Sigma's project area</td>
<td>Improve capacity (increase sales); improve quality and customer satisfaction; reduced costs; increased cash flow</td>
</tr>
</tbody>
</table>

It was found that the different project selection aspects in table 13 provide further description for the *sub-criteria* in table 12, which means that project selection aspects in table 13 are the *variables*. For example: variables such as “customer satisfaction” and “delivery time” (Banuelas Coronado and Antony, 2002) may construct the sub-criteria “customer
oriented” (Kwak and Anbari, 2006) or “impact on meeting external customer requirement” (Pande et al, 2000). Another example is variables such as “net cost saving” (Harry and Schroeder, 2000), “reduce cost” (Snee and Rodebaugh Jr, 2002), and “increased cash flow” (Snee and Rodebaugh Jr, 2002) may provide explanation for “financial impact” sub-criteria.

There are some project selection aspects in table 13 (e.g. employee satisfaction and risks) that complement the Six Sigma project selection structure (in table 12) although it was not yet clear whether these aspects should be identified as sub-criteria or variable. With this consideration, these aspects are added and appropriately placed in the hierarchical classification. Table 14 shows the hierarchy of project selection aspects after adjustment.

Defining the components of OPB and OPE
The criteria level provides an insight of the value concept, in the sense that selecting an improvement project is a "trade-off" between the [perceived] benefits (i.e. business-related, organisation-related) gained from improvement projects and the [perceived] efforts to perform the improvement projects (i.e. the feasibility).

Most of Six Sigma project selection processes use aspects at the variable level of categorisation, sometimes both at variable and sub-criteria levels. Although the variable level may be attractive to use, because it provides detail or clarity in description, using the variable level of categorisation to asses proactive improvement projects could be "over promising" (less realistic) because during the project selection process, the impacts of an improvement project are still perceived (i.e. not yet gained or realised). Using the project selection aspects from the variable level may also be misleading due to redundancy and/or correlation between variables, for example: reliability, variability, defect, and yield – all these words refer to and construct the term quality. Thus, it would be more realistic to state that an improvement project has impacts on internal performance [sub-criteria] in terms of quality [variable] rather than an improvement project has impacts on reliability [variable], variability [variable], and defect [variable]. Therefore, it is suggested that proactive improvement projects
in Six Sigma and Lean Production should be selected based on selection aspects at the sub-criteria level.

Table 14. The hierarchy of project selection aspects

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Sub-criteria</th>
<th>Variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Business related</td>
<td>External customers</td>
<td>Customer satisfaction; delivery time</td>
</tr>
<tr>
<td></td>
<td>Financial</td>
<td>Cost saving/reduction; cost avoidance; improve cash flow</td>
</tr>
<tr>
<td></td>
<td>Core competence</td>
<td>Quality (in terms of dpmo; reliability; yield; waste; variability) and productivity (in terms of capacity; cycle time; inventory)</td>
</tr>
<tr>
<td></td>
<td>Strategic goals</td>
<td>Market share; sales; competitiveness; market positioning</td>
</tr>
<tr>
<td>Organisation</td>
<td>Cross functional</td>
<td>Cross functional</td>
</tr>
<tr>
<td>related</td>
<td>Learning (competence &amp; skill)</td>
<td>Learning (competence &amp; skill)</td>
</tr>
<tr>
<td></td>
<td>Employee satisfaction</td>
<td>Employee satisfaction</td>
</tr>
<tr>
<td>Feasibility</td>
<td>Project description</td>
<td>Scope &amp; focus; output/outcome; definition/formulation</td>
</tr>
<tr>
<td></td>
<td>Resource and capital</td>
<td>Resource &amp; budget; expertise; completion time</td>
</tr>
<tr>
<td></td>
<td>Psychology</td>
<td>Team readiness and motivation; leadership</td>
</tr>
<tr>
<td></td>
<td>Risk</td>
<td>Complexity; resistance against changes</td>
</tr>
</tbody>
</table>

On the other hand, the variable level is useful when identifying the relative importance of a certain aspect of the project selection because it may reflect specific preferred goals to be achieved through improvement projects.

Thus, based on table 14, it is suggested that OPB is about the benefits of improvement projects on business and the organisation, while the OPE deals with the feasibility of improvement projects. OPB may include the
impacts of improvement projects on external customers, financial, strategic goals, cross-functionality, learning, and employee satisfaction. On the other hand, assessing the project’s feasibility (OPE) includes the following: project description, resource and capital, psychology, and risk.

5.5 Control

In order to demonstrate and to self-evaluate producers’ capability or competencies in providing fair customer value for own customers, it is necessary to monitor customer value over time, using control charts. Customer value at period \( t \) (CV\(_t\)) is calculated as:

\[
CV_t = \frac{\sum_{i=1}^{n} CV_i}{n}
\]  

(13)

Where:
- \( CV_i \): The i-th customer’s individual perception of the product’s value
- \( t \): 1, 2, ..., \( k \)
- \( k \): Number of measurement periods
- \( n \): Number of customers to be measured each period (sample size)

The producer is judged as capable to provide fair customer value if all measurements are inside the control limits, where the limits are:

\[
CV \pm \frac{3s}{\sqrt{n}}
\]  

(14)

Or

\[
\left( \frac{\sum_{t=1}^{k} CV_t}{k} \right) \pm \frac{3}{\sqrt{n}} \sqrt{\frac{\sum_{t=1}^{k} \left( \sum_{i=1}^{n} (CV_{it} - CV_t) \right)^2}{k-1}}
\]  

(15)

Where:
- \( CV_{it} \): Measured product’s value as perceived by customer i at period \( t \)
Let’s assume that $\pm 3$ sigma is the specification limits of fair customer value. Given that an *adjusted capability index* ($C_{pk}$) is a ratio between the distance of upper specification limit from the target value (i.e. half of specification range) and three (3) times standard deviation, this reasoning will result on $C_{pk} = 1$, which means that although the producer is capable to create/deliver fair value, the capability just fulfils the minimum requirement. The producer may need to narrow the limits of the control chart (into e.g. $\pm 2s$) when the producer considers: 1) the *risk* for $\alpha$ and $\beta$ errors and the financial consequences (due to the fact that the “actual” zone of fairness for an individual customer can be broader or narrower than $\pm 3$ sigma), and 2) the *commitment to improvement*.

Let’s define that $H_0$: the value creation process is in control and $H_1$: the value creation process is out of control. $\alpha$-type error occurs when deciding that the process is out of control while it is in control. Thus, this type of error may cause *overestimation of potential profits* (because the producer thinks that the product is of high value for the customers while it is not the case) and *potential losses* (because the producer thinks that the product is of low value for the customers while it is not the case). $\beta$-type error occurs when the producer decides that the process is in control while it is out of control. This type of error thus causes *underestimation of potential profits* (because the producer still thinks that the product is of fair value while the customers perceive the products as of high value) and *potential losses* (because the producer does not realise that customers have already perceived that the product’s value is low). We may notice that $\beta$-type error has a more severe impact than $\alpha$-type error. Therefore, narrowing the limits of the control chart may help the producers to reduce the consequences of $\beta$-type error.

Given that the specifications limits are still within $\pm 3$ sigma, narrowing the limits of the control chart may also indicate producer’s commitment to improve performance because when all customer value measurements are within a narrower control limits (e.g. $\pm 2$ sigma), a higher capability index can be achieved.
Further description regarding the application of control charts to monitor customer value over time can be seen in paper V.
6. The development of backward-looking quality management toward customer value creation

The development of backward-looking quality management toward customer value creation is basically the underlying theme of papers III, IV, and V, where the transformation process is described by the five principles of the Lean Production methodology (see e.g. Womack and Jones, 1996): define customer value, identify value stream, making the value creating steps flow, let the end customers pull the product from the value stream, and pursue perfection.

When applied in customer-value research and based on the study conducted in a Swedish wood flooring manufacturer, the third and fourth principles above need further reflections, in the sense that: 1) in order to make value-creating steps flow (3rd principle), it is necessary to first identify (and estimate the amount of) waste according to the waste criteria, and 2) what the customers actually pull is value, which is inherent in the process and product (4th principle).

Table 15 shows a re-interpretation of five principles of Lean Production methodology.

<table>
<thead>
<tr>
<th>Principle</th>
<th>Re-interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>Define customer value</td>
</tr>
<tr>
<td>Identify</td>
<td>Identify the value stream(s)</td>
</tr>
<tr>
<td>Flow</td>
<td>Identify waste that slows the flow of values</td>
</tr>
<tr>
<td>Pull</td>
<td>Measure the added value to be pulled by customers</td>
</tr>
<tr>
<td>Perfection</td>
<td>Perfection in adding value to customers by nominating, selecting, and executing improvement projects</td>
</tr>
</tbody>
</table>

6.1 Define

Backward-looking quality management basically addresses the “other side of the value-coin”, i.e. “waste”, a term that is often discussed in relation
with the Lean Production methodology, refers to “everything” that the customers do not value (appreciate). By referring to Holbrook (1999) and Möller and Törrönen (2003), customer value can be explained by the notion of efficiency. The existence of waste thus does not create value because waste becomes an obstacle for efficient processing or efficient use of a product.

However, interpreting customer value as elimination of waste does not explain the essence of customer value itself, in the sense that there is a risk that producers and customers define value in different ways (the value paradox) because the way producers define critical-to-quality criteria (CTQ) may not be based on the values that are critical for customers. Therefore, in paper V, it is suggested that the producers identify critical values (i.e. functional utilities or a definition of customer value that compromises between producers’ and customers’ interests) as the basis to determine the critical quality characteristics for customer value creation (CTQs).

It may not be an uncommon practice that customer value is identified indirectly, which means that customer value is identified based on the supplier’s assumption (perception) of what the customer might value (Näslund et al. (2006) seems to be an example of this practice). If the producer has sufficient and correct knowledge about what the customers do value, this practice is acceptable, otherwise the result may be misleading.

The development of the added value metric (paper III) is an attempt to link backward-looking quality management and customer value, in which the added value metric identifies waste along the value stream and implying on the value that can be pulled by customers from the production process.

6.2 Identify

Identifying the value stream basically involves determining and mapping the process. Studying the value stream may concern a particular cost object, i.e. the output of a cost system for which activities are performed, such as products and services.
An empirical study to measure added value in a Swedish wood-flooring manufacturer was conducted, where the identified value stream starts after the semi-finished wood-flooring boards are received and stored, and the value stream ends right before the final inspection (see figure 14). The scope of the measurement was further narrowed by only looking at a particular cost object, the 2-strip, wide, 7 mm walnut wood flooring product.

Figure 14. The value stream
6.3 Flow

The third principle of Lean Production is to create a smooth “flow” along the value stream. However, the value stream cannot run smoothly if there is waste, and waste will reduce the value pulled (from the process) by customers. Therefore, it is necessary to understand and identify different types of waste along the value stream that slows the flow (see table 16).

<table>
<thead>
<tr>
<th>Visible waste</th>
<th>Waste criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-conformities</td>
<td>Imperfections (defects), incorrect processing</td>
</tr>
<tr>
<td>Reworks</td>
<td>Imperfections, incorrect processing</td>
</tr>
<tr>
<td>Failures and stoppages (idles)</td>
<td>Incorrect processing</td>
</tr>
<tr>
<td>Non value added labour</td>
<td>Waiting, unnecessary movements, defects</td>
</tr>
<tr>
<td>Excess inventories</td>
<td>Unnecessary transports, Overproduction, Excess inventory</td>
</tr>
<tr>
<td>Tardiness</td>
<td>Unnecessary transports, Overproduction, Excess inventory</td>
</tr>
</tbody>
</table>

The result of actual work sampling (table 17) provides an approximation regarding waste within operators’ activities. Waste within and between processes were identified and stated in terms of non value-added costs (see table 6 in chapter 3).
Table 17. Actual work sampling

<table>
<thead>
<tr>
<th>Activity</th>
<th>May 2006 (%)</th>
<th>August 2006 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Added value</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Processing-related</td>
<td>22.48</td>
<td>16.92</td>
</tr>
<tr>
<td>Preventive (precautionary) activities</td>
<td>4.13</td>
<td>16.54</td>
</tr>
<tr>
<td><strong>Non value added (necessary)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Setting up</td>
<td>7.62</td>
<td>3.88</td>
</tr>
<tr>
<td>Monitor production</td>
<td>32.30</td>
<td>17.18</td>
</tr>
<tr>
<td>Testing and control</td>
<td>15.50</td>
<td>23.64</td>
</tr>
<tr>
<td>Investigate and repair failures</td>
<td>5.94</td>
<td>8.27</td>
</tr>
<tr>
<td>Administrative</td>
<td>9.17</td>
<td>1.68</td>
</tr>
<tr>
<td><strong>Pure waste</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waiting</td>
<td>2.07</td>
<td>9.30</td>
</tr>
<tr>
<td>Away (cannot be contacted)</td>
<td>0.78</td>
<td>2.58</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

6.4 Pull

The term “pull” implies that added value will likely be pulled by the customers from the process. This requires the producer to measure added value, which consists of quality, time, and non value-added costs in relative terms, meaning that the measurement of added value is a ratio of the performance metric at the current period (i+1) and the previous period (i). Thus, added value (AV) is defined as:

$$ AV = \frac{Q_r * T_r}{C_r} $$

(16)

Where:

- $Q_r$: Relative performance of quality
- $T_r$: Relative performance of time
- $C_r$: Relative performance regarding non value added costs

In case that the added value exceeds 100%, it means that at period (i+1) the customers has been able to pull more value from the process compared to period i because waste in the process decreased. If the added value is
less than 100%, it means that at period (i+1) the customers pulled less value from the process compared to period i because of more waste in the process.

Relative performance of quality ($Q_r$) can be defined as the ratio between the yield ($Y$) at period (i+1) and yield at period (i). Yield is defined as the percentage of output that conforms to the specifications, i.e. the ratio between the amount of acceptable products and the total amount produced. Then:

$$Q_r = \frac{Y_{i+1}}{Y_i}$$  \hspace{1cm} (17)

Based on the model of measuring quality performance (figure 6 in chapter 3), the incoming quality was estimated by calculating the ratio between the amount of supplier-caused defects and the total produced products, where the incoming quality decreased from 93% (in May) to 88% (in August). The quality performance of the cost object (372085VA) is thus the yield after the last process ($y$), where it decreased from 90.91% in May to 84.44% in August. Based on equation (2) and (3) with $k = 2$, the estimated average defect rate in either surface treatment or profiling process ($d_{\text{average}}$) is equal to 1.24% (in May) and 2.40% (in August).

Waste does not only influence cost, but it also causes a longer cycle times than necessary (due to the time consumed by non-value added activities). Therefore, cycle time ($T_c$) can be generally expressed as a sum between value-added time ($T_{VA}$) and non-value added time ($T_{\text{NA}}$). A more effective and efficient operation is expected to reduce the non-value added time, and therefore reduce cycle time. Hence:

$$T_c = T_{VA} + T_{\text{NA}}$$  \hspace{1cm} (18)

From (18), we define the fraction of value added time ($v$), which is defined as a ratio between value-added time ($T_{VA}$) and the cycle time ($T_c$). Hence:
Relative performance of time \( (T_r) \) is defined as a ratio between the fraction of value-added time \((v)\) at period \((i+1)\) and the fraction of value added time at period \((i)\). Then:

\[
T_r = \frac{v_{i+1}}{v_i}
\]

Therefore:

\[
T_r = \frac{\frac{T_{VA(i+1)}}{T_{C(i+1)}}}{\frac{T_{VA(i)}}{T_{C(i)}}} = \frac{T_{VA(i+1)}}{T_{VA(i)}} \times \frac{T_{C(i)}}{T_{C(i+1)}}
\]

The analytical model of the added value in (16) was tested in a production process of the Swedish wood-flooring manufacturer by measuring the percentage of products that fulfils requirements \((Y)\), the fraction of value added time \((v)\), and the non value added costs \((C_{VA})\) in two different periods.

Table 18 provides the measurements of value added time and cycle time in May and August 2006.

The relative performance of cost \( (C_r) \) is defined as the ratio between non-value added costs \((C_{VA})\) at period \((i+1)\) and non-value added costs at period \((i)\). Then:

\[
C_r = \frac{C_{VA(i+1)}}{C_{VA(i)}} = \frac{COQ_{i+1}}{COQ_i}
\]

The amount of non value-added costs in May 2006 were equivalent to the monthly salary of three (3) production workers (assuming that these workers are working 40 hours per week), while the amount of non value
added costs in August 2006 were equal to the salary of four (4) production workers.

Table 18. Measurements of value added time and cycle time

<table>
<thead>
<tr>
<th>Quantity (m²)</th>
<th>Value added time (minutes)</th>
<th>Cycle time (minutes)</th>
<th>v (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>May 2006</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>708</td>
<td>112.64</td>
<td>6348</td>
<td>1.77</td>
</tr>
<tr>
<td>944</td>
<td>150.18</td>
<td>5879</td>
<td>2.55</td>
</tr>
<tr>
<td>1416</td>
<td>225.27</td>
<td>9402</td>
<td>2.40</td>
</tr>
<tr>
<td>472</td>
<td>75.09</td>
<td>3607</td>
<td>2.08</td>
</tr>
<tr>
<td>1652</td>
<td>262.82</td>
<td>731</td>
<td>35.95</td>
</tr>
<tr>
<td>Average</td>
<td>0.16</td>
<td>5.00</td>
<td>3.18</td>
</tr>
</tbody>
</table>

| August 2006   |                            |                      |      |
| 1652          | 262.82                     | 10090                | 2.60 |
| 826           | 131.41                     | 5176                 | 2.54 |
| 1180          | 187.73                     | 2325                 | 8.07 |
| 944           | 150.18                     | 14480                | 1.04 |
| 708           | 112.64                     | 6238                 | 1.81 |
| Average       | 0.16                       | 7.21                 | 2.21 |

The result of data collection is summarised in table 19, where Y decreased from 90.91% to 84.44%, v decreased from 3.18% to 2.21%, and $C_{Fi}$ increased from the monthly salary of three (3) production workers to approximately the monthly salary of four (4) production workers.

Table 19. Summarized data of added value variables

<table>
<thead>
<tr>
<th></th>
<th>May 2006</th>
<th>August 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relative quality</td>
<td>%</td>
<td>90.91</td>
</tr>
<tr>
<td>performance (Qr)</td>
<td></td>
<td>84.44</td>
</tr>
<tr>
<td>Relative time</td>
<td>%</td>
<td>3.18</td>
</tr>
<tr>
<td>performance (Tr)</td>
<td></td>
<td>2.21</td>
</tr>
<tr>
<td>Relative cost</td>
<td>SEK</td>
<td>≈ Monthly salary of 3</td>
</tr>
<tr>
<td>performance (Cr)</td>
<td></td>
<td>production workers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>≈ Monthly salary of 4</td>
</tr>
<tr>
<td></td>
<td></td>
<td>production workers</td>
</tr>
</tbody>
</table>
The added value metric suggests that the value customers “pulled” from the process during August 2006 was 50.18% of the value that they pulled from the process during May 2006 (given the assumption that the added value pulled from the process was 100% in May 2006). In other words, the value that was pulled from the process in August 2006 was 49.82% less than the value that is pulled from the process in May 2006 (i.e. 100% – 50.18%). Thus, the added value metric indicates how “severe” the effects or consequences of waste are. In general, the added value provides a more adequate way of measuring performance, compared to “ordinary” performance measures such as poor quality costs, defects [in Six Sigma], or cycle time [in Lean Production]. Measuring quality costs, defects, or cycle time is valuable, but the association with customer value is implicit, unless these measurements are transformed into a “new”, integrated metric.

The process of measuring added value indicates the areas or activities in the company which have performance gaps (ineffective) and “tracks” the potential causes to be understood and controlled in order to strive towards perfection.

6.5 Perfection

Striving towards perfection in adding customer value is a series of project nominations, selection and execution. It is suggested that improvement projects should be distinguished into proactive and reactive projects (paper IV).

6.5.1 Project nomination

Proactive improvement project

Comparing the measurements of added value in a key process in the case company in May and August 2006 indicated that every component of added value is deteriorating, i.e. decreased yield, longer cycle time, and increased non-value added costs. These phenomena were analysed using the "5 Why's" in order to be able to identify the potential causes behind the phenomena (see table 20).
Table 20. Potential causes of decreasing added value

<table>
<thead>
<tr>
<th></th>
<th>Deteriorating Quality</th>
<th>Longer Time</th>
<th>Increasing Costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHY</td>
<td>1a. Because the quality of incoming goods had been decreasing.</td>
<td>1a. Because the waiting time in the production is significantly long.</td>
<td>1. Because the costs due to non-conformities are high.</td>
</tr>
<tr>
<td></td>
<td>1b. Because the level of non-conformities in the processing increased.</td>
<td>1b. Because the process has been inefficient (producing more non-conforming</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>goods).</td>
<td></td>
</tr>
<tr>
<td>WHY</td>
<td>2a. Because the procedure for incoming quality is not yet well established.</td>
<td>2a. Because sudden (&quot;last minutes&quot;) changes of production plan occur frequently.</td>
<td>2. Because the quality of incoming goods as well as the process quality had been</td>
</tr>
<tr>
<td></td>
<td>2b. Because all incoming materials (whether conforming or non-conforming) were</td>
<td>2b. Because there might be improper machine settings or human errors.</td>
<td>decreasing.</td>
</tr>
<tr>
<td></td>
<td>processed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3a. Because the company isn't quite aware that the problems caused by suppliers are</td>
<td>3a. Because the changes of customer demand and preferences couldn't be captured as early as possible.</td>
<td>3. Because the supplier and the company might have different expectations regarding quality.</td>
</tr>
<tr>
<td></td>
<td>significant.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3b. Because of the absence of inspection or quality control activities prior to the</td>
<td>3b. Because the training given to the operators might be inadequate.</td>
<td></td>
</tr>
<tr>
<td></td>
<td>process.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The analysis of the added value measurements led to the nomination of two improvement projects: *Supplier Quality Assurance* (SQA) and *Productive Customer Response* (PCR).
The main purpose of Supplier Quality Assurance is to assure the quality of incoming material from the suppliers through the development of procedures and actions as well as cooperation with the suppliers. The SQA project thus implies that customer value creation may involve other “actors” in the supply chain.

The main purpose of Productive Customer Response (PCR) is to capture (identify) the dynamics of customer demands and preferences, which allows the producer to respond effectively and efficiently. The PCR project is consistent with Dumond (2000) and Flint & Woodruff (2001) regarding the need of a system that captures customer value and its dynamics that enable producers to response. Responsiveness to customer needs is an important aspect in the future definition of quality (Mehra et al, 2001).

Regardless which project will be selected, further formulation of the project in terms of the creation of modules is required.

Reactive improvement project
For the purpose of comparison, the nomination of reactive improvement projects is also described. Measuring the costs due to defects leads to the identification of reactive improvement projects, where the nominated improvement projects are the result of identifying failure types or modes.

The quality cost report of the year 2004 indicated that internal failure costs were larger than the external failure cost, which indicates that reduction of internal failure cost should have the highest priority. It was found that costs due to scrap of finished products was the largest cost component within the internal failure costs. Finished products of the case company can be categorized into one-strip (1), two-strip (2), and three-strip (3) wood-flooring products. One-strip products are "thin" wood floor (around 7 mm), which consists of three layers of wood veneers or "thick" wooden floor (around 15 mm), while two-strip and three-strip products are only "thick" wooden floors (around 15 mm), and usually consist of three layers of joined wood panels. Each product group has a final processing in the main factory in region “N”, and it may arrive as work-in-process (WIP) from several branch factories in, e.g. region “L” and “R”. The factory in region L supplies mostly the one-strip products to the main factory (in
region N), while the factory in region R mostly produces three-strip products, and the major products of the main factory are two-strip and three-strip products.

From the internal defect reports during the period January to April 2005, it was found that one-strip products had the largest defect rate and the largest reject costs compared to the two-strip and three-strip products (see table 21).

Table 21. Defect rate and cost due to scrap according to product group

<table>
<thead>
<tr>
<th>Product group</th>
<th>Defect rate (% of volume produced in m²)</th>
<th>Cost (% of production cost)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1L</td>
<td>6.3</td>
<td>7.19</td>
</tr>
<tr>
<td>2N</td>
<td>0.76</td>
<td>0.69</td>
</tr>
<tr>
<td>3N</td>
<td>0.45</td>
<td>0.43</td>
</tr>
<tr>
<td>3R</td>
<td>0.12</td>
<td>0.13</td>
</tr>
</tbody>
</table>

The registrations show that the high reject level on one-strip products is mostly due to defects on the wearing surface (stated as failure code 3). However, it is difficult to identify the specific type of defect because the defects are only registered with the amount (m²) and the percentage of rejects for each failure code (general types of faults), while in a failure code, there might be several modes of failures. Additionally, the recorded defect is based on the type of defect first seen by the inspectors although there may be several other defect types in a rejected product.

Due to the above reasons, it was decided to collect 100 random samples of 15 mm, one-strip products (from several pallets from different production batches) and thoroughly examined them in order to find more detailed information about the types of defects. The selected samples were mostly oak wood-flooring products because around 80% of one-strip products use oak wood as the raw material. From 100 samples checked, 120 defects were found, which means that (in average) there is more than one type of defect in a product. The top 10 failure types are presented in table 22.

The findings suggest that: 1) the largest defect (main problem) of one-strip products is the holes or cracks from the twig that was unfilled during the
filling process, and 2) failures in the filling process also appear as several other failure types, e.g. oversize filling and inadequate filling.

Table 22. Failure types and the percentage distribution

<table>
<thead>
<tr>
<th>Failures</th>
<th>Proportion (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unfilled holes from the twig</td>
<td>23</td>
</tr>
<tr>
<td>Dimension fault</td>
<td>13</td>
</tr>
<tr>
<td>Pressure marks</td>
<td>10</td>
</tr>
<tr>
<td>Unfilled cracks around the twig</td>
<td>9</td>
</tr>
<tr>
<td>Holes or cracks (from the twig) on the sides</td>
<td>8</td>
</tr>
<tr>
<td>Discoloration</td>
<td>7</td>
</tr>
<tr>
<td>Broken middle layer</td>
<td>6</td>
</tr>
<tr>
<td>Incorrect colour composition (aesthetic fault)</td>
<td>6</td>
</tr>
<tr>
<td>Oversize filling</td>
<td>3</td>
</tr>
<tr>
<td>Inadequate (improper) filling</td>
<td>3</td>
</tr>
</tbody>
</table>

A good (Six Sigma) improvement project has a clear connection with the business strategy and/or customer needs (Breyfogle et al, 2001; Snee, 2001), or closely tied to strategic improvement needs and organization's priorities (Antony et al, 2004). Therefore, it was decided to have dialogues with various persons in the case company (i.e. the sales manager, product manager, quality manager, and the manager for technical support) to identify customer needs and the business strategy. The results of the dialogues were used as a reference to "confirm" the appropriateness of the selected improvement project, i.e. the selected project has connection with customer needs, business strategy, strategic improvement, or priorities of the organization. The dialogues can be summarized as follows:

a) Customer requirements and product quality dimensions

Functionality (e.g. specification/precision of the dimension, adaptability in different moisture conditions, easy to clean), aesthetic or appearance (e.g. uniform gloss of the wood-flooding surface, right colour combination, smoothness, free from cracks), and delivery time are the characteristics used by customers to judge product (and company's overall) quality. Competitive prices and after sales services are additional important customer requirements.

b) Strategic improvement needs and organization's priority

The two-strip and three-strip products have "low" profit margins and "low" product complexity (in terms of product feature and the complexity of surface
treatment process); while one-strip products are products with "higher" profit margins and "higher" product complexity. Product development and innovations on one-strip products will likely provide more value for the firm and the customers due to a better fulfilment of customer requirements.

Hence, it can be "confirmed" that the case company has selected a good project since the project is dealing with a chronic problem, related to customer needs (requirements) and the business strategy. Therefore, the selected improvement project will likely add value to both internal customers and external customers.

6.5.2 Project selection

Proactive improvement project

The project is selected based on perceived added value (see paper IV), which indicates the potential for creating value to customers.

Managers’ opinions regarding their perception of project benefits and the efforts to perform the project, as well as the importance weight of those benefits and efforts were identified. The results are summarised in tables 23 and 24.

Table 23. The perceived benefits of nominated improvement projects

<table>
<thead>
<tr>
<th>Benefits to organisation (functional cooperation, learning, and employee satisfaction)</th>
<th>Weight</th>
<th>SQA</th>
<th>PCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>External customers (customer satisfaction and delivery time)</td>
<td>0.2174</td>
<td>0.7917</td>
<td>0.8750</td>
</tr>
<tr>
<td>Financial (cost saving/reduction, cost avoidance, and cash flow improvement)</td>
<td>0.2037</td>
<td>0.8333</td>
<td>0.8750</td>
</tr>
<tr>
<td>Internal performance (quality &amp; productivity)</td>
<td>0.2233</td>
<td>0.8333</td>
<td>0.8333</td>
</tr>
<tr>
<td>Strategic goals (sales, market and competitiveness)</td>
<td>0.1910</td>
<td>0.7083</td>
<td>0.8750</td>
</tr>
<tr>
<td>Benefits to organisation (functional cooperation, learning, and employee satisfaction)</td>
<td>0.1645</td>
<td>0.5833</td>
<td>0.7083</td>
</tr>
</tbody>
</table>
Table 24. The perceived efforts of nominated improvement projects

<table>
<thead>
<tr>
<th>Project description</th>
<th>Weight</th>
<th>SQA</th>
<th>PCR</th>
</tr>
</thead>
<tbody>
<tr>
<td>(scope/focus, formulation, and defined output)</td>
<td>0.2656</td>
<td>0.5000</td>
<td>0.7083</td>
</tr>
<tr>
<td>Resources &amp; capital (budget, expertise, project duration)</td>
<td>0.2543</td>
<td>0.4853</td>
<td>0.7083</td>
</tr>
<tr>
<td>Psychological (team's readiness and motivation, leadership)</td>
<td>0.2622</td>
<td>0.5833</td>
<td>0.7083</td>
</tr>
<tr>
<td>Risk (project complexity and resistance for changes)</td>
<td>0.2179</td>
<td>0.3333</td>
<td>0.7083</td>
</tr>
</tbody>
</table>

By combining the measurements in tables 23 and 24, the perceived-added-value score (calculated according to equation (9)) for the SQA project is 1.5985 and for the PCR project is 1.1833. Since the SQA project has the highest score on perceived added value to customers, this project should be given first priority for implementation.

Reactive improvement project
In contrast to the proactive improvement projects, the selection of reactive improvement projects usually involves Pareto charts and customer requirement (or business strategy). The selected improvement project was “reduction of the percentage or level of rejects due to unfilled holes from the twig by improving the filling process”.

Comparison between reactive and proactive improvement projects
Although both reactive and proactive improvement projects were identified based on performance measurements, those projects are different with respect to aspects such as output, area covered, etc.

Each type of improvements follows different roadmap. The most apparent/obvious difference between reactive and proactive improvement projects is that reactive improvement projects provide guidance of what should be done to solve the problem, while proactive improvement projects provide guidance of what could be done to retain or improve the performance.
People working with reactive improvement projects may be aware of the existence of problems or symptoms, while it may not always be the case in proactive improvement projects. A reactive improvement project is likely a single project within a department (function), while a proactive improvement project may consist of several "modules" that involves cross-functionality. The aspects to select reactive improvement projects are usually chosen from the variable level, and thus it becomes natural to check whether the selected project adds value or not. On the other hand, the aspects to select proactive improvement projects are chosen from the sub-criteria level, so the selected improvement project indicates that the project is perceived as having the biggest potential to add value to the customers because the hierarchical structure of project selection aspects accommodate the value concept (which is not yet addressed by existing ways of selecting project in Six Sigma). Table 25 summarises the differences between proactive and reactive improvement projects.

Table 25. Differences between reactive and proactive improvement projects

<table>
<thead>
<tr>
<th></th>
<th>Reactive</th>
<th>Proactive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output</td>
<td>What should be done</td>
<td>What could be done</td>
</tr>
<tr>
<td>Level of awareness to the &quot;symptom&quot;</td>
<td>Higher</td>
<td>Lower</td>
</tr>
<tr>
<td>Content</td>
<td>Single</td>
<td>Modules</td>
</tr>
<tr>
<td>Area covered</td>
<td>Functional</td>
<td>Cross-functional</td>
</tr>
<tr>
<td>Level of selection aspects</td>
<td>Variables</td>
<td>Sub-criteria</td>
</tr>
<tr>
<td>Value orientation</td>
<td>Checked</td>
<td>&quot;Built-in&quot;</td>
</tr>
</tbody>
</table>

Each type of improvement project adds value in different ways. Reactive improvement projects add value if the projects are [qualitatively] judged as relevant to the business strategy or critical for customer requirements. On the other hand, proactive improvement projects add value if the perceived benefits gained from the projects exceed the perceived efforts to perform the projects.
7 Conclusions, implications and future research

7.1 Conclusions

This dissertation indicates that customer focus means understanding “things” (e.g. needs, goals) that customers do value and utilise that knowledge to develop and improve the output and processes of value creation.

Customer value is a very complex concept, in which various aspects (such as its nature, dimensions, levels of abstraction, forms, and contents) contribute to its complexity. Thus, there may not be a single definition that is able to adequately describe what customer value is.

Perceived customer value is the customer’s cognitive judgements on products or services, an assessment that is based on a comparison between “benefits” and “sacrifices”. In the purchase situation (in oligopoly and perfect-competition markets), customers compare \(\frac{\text{market perceived quality}}{\text{market perceived price}}\). This model has its

\(\text{Not applicable in monopoly}\)

** “Few” (in oligopoly) and ”many” (in perfect competition)
limitation in situations where the product’s life cycle cost needs to be taken into account. Therefore, the PCV has been redefined as a ratio between customer’s cognitive judgement on quality (CCJQ) and the customer’s cognitive judgement on cost (CCJC).

Received customer value is also defined as a ratio between benefits and sacrifices. However, the benefits and sacrifices should reflect the use-experience (situation). In the use situation, customers make a judgment whether the consequences of using the product will fulfil their needs or help them in achieving their goals. Therefore, the benefit-related variables should reflect the consequences of using a product, instead of the attributes. If the consequences have not yet fulfilled customers’ needs or goals, the producer should improve the product attributes that are leading to the intended (preferred) consequences.

It should be remembered that the producer may not be able to influence the upper level of the value hierarchy or means-end model (see figure 1 in paper V). Hence, producers and customers should find a common (compromised) definition regarding what values are sought from the use (consumption) of a product. It has been suggested in paper V that functional utilities should be used when defining the “benefits” because functional utilities are perceived by customers yet can be influenced by the producers.

In the use situation, customers are likely using one product, chosen from several competing products during the purchase stage. Therefore, RCV has been built based on the reasoning that customers compare the benefits and the sacrifices of a single product (referred to as a non-competition context), where it is defined as a ratio between customers’ perceptions on functional utilities and (life cycle) cost.

This dissertation highlights another way of defining customer value, that customer value is the customer’s cognitive judgement on supplier’s (producer’s) competencies. Supplier’s competencies, which consist of efficiency, effectiveness, and network coverage, are needed to create these types of value: core value, added value, and future value (Möller and Törrönen, 2003). The efficiency, effectiveness, and network coverage are very similar to added value, customer value in production context, which
has been conceptually defined by Womack & Jones (1996) and Harry Crawford (2005). Since this type of value (Möller and Törrönen, 2003) can be linked to Grönroos (1997) model that perceived customer value is core value ± added value, customer value in the market is actually not disconnected from customer value in the production.

Defining customer value as the customer’s cognitive judgment on supplier’s competencies implies that suppliers should manage quality in such a way that it leads to the creation of core customer value and added customer value. Thus, creating value means fulfilling customer needs/goals and continuously improving the attempts or the efforts to fulfil those needs/goals. Continuous improvements are conducted through improvement projects that are nominated and selected based on their potential impacts on adding value (perceived added value).

The existing body of knowledge of customer value has, since long time ago, “acknowledged” that quality is an important component of customer value. This acknowledgement is well-suited with the claim that the aim of quality management is to create value to customers. However, existing methods of quality management (TQM, Six Sigma, and Lean Production) are often judged as having “failed” in implementing the strategic aspects of value creation into an operational level. This may be caused by the fact that although those quality management methods claim customer focus, they have difficulties in operationalising the term and identifying the prerequisites.

Consequently, quality management should be further developed towards customer value creation, where Profound Knowledge of Customer Value (PKCV), i.e. appreciation for a value-creating system, knowledge about customer value “modes”, theory of improvements, and perception, provides the underlying principles of the development. Appreciation for a value-creating system implies that an organisation is a value-creating system, where customer value is both input and output of the system. This appreciation requires knowledge regarding customer value in different “modes” (i.e. received customer value, perceived customer value, added value) and that those value modes are interconnected. Theory of improvements describes that quality improvements may influence customers’ perceptions of value. In the theory of improvements, big Q and
little Q improvement projects are further distinguished into proactive and reactive, which follow different roadmaps. *Perception* indicates the necessity of studying customers’ perceptions (minds) to gain financial rewards (shareholder value).

Since quality concept can be distinguished between forward-looking quality and backward-looking quality, the development of quality management toward customer value creation follows this categorisation.

The development of forward-looking quality management toward value creation follows the principles of Six Sigma: *define, measure, analyse, improve*, and *control*. Here, customer value is defined as (refers to) perceived and received customer value, where both are measured according to the trade-off form (i.e. as a ratio between benefits and sacrifices). Analysing these measurements means finding measurements that are below the lower limit of the zone of fairness, which thus indicate opportunities for improvement. Improving customer value is conducted by nominating and selecting improvement projects. Control means measuring customer value over time in order to monitor producer’s performance in creating or delivering value.

The development of backward-looking quality management toward value creation follows the principles of Lean Production: *define, identify, flow, pull, and perfection*. Value is defined as the reduction or absence of “waste” (e.g. defects, over production, waiting, unnecessary transports, etc) in a specifically identified process. The existence of waste in a process slows the flow of value in the process, thus it should be recognised and identified and quantified. Otherwise, waste will reduce the value that customers pull from the process. In order to prevent (avoid) pulled value being reduced, improvements towards perfection are necessary. Based on a study in a Swedish wood flooring manufacturer, the consequence of waste can be so severe that the pulled value from the process was reduced by approximately 50%. Using the “5 why’s” tool, it was found that improper production planning (due to inability to capture the changes of customer demand and preferences) and managing supplier quality may cause a high amount of waste in the process.
The lessons learned from the development of quality management toward value creation are: 1) the development does not require searching for another philosophy, rather it follows (can be explained by) the principles of the “new” TQM paths (i.e. Six Sigma and Lean Production methodologies) although it is necessary to re-interpret and deeply reflect the underlying principles of those methodologies, and 2) the development indicates that quality management needs to adapt tools from, e.g. marketing, in order to capture customer value.

7.2 The contributions of the dissertation

According to Conti (2006), a new paradigm, based on system thinking, is needed in order to understand the full meaning of quality and quality management concepts as well as to extend quality management concepts into stakeholder value creation. This dissertation can be considered as a contribution to the development of a new quality management paradigm, by introducing the **Profound Knowledge of Customer Value** (PKCV), a guideline for developing quality management toward customer value creation.

In this dissertation, the development of quality management toward customer value creation has been influenced by a system perspective, in the sense that although customer value is a multifaceted-concept, those different definitions are interconnected. Hence, adopting system theory (approach) enables the coherence or consistency in conceptualising customer value in different contexts. This way of thinking may enable us to address theoretical gaps (inconsistencies) that: customer value has been the ultimate (strategic) goal of quality management but has not yet been manifested at the operative (tactical) level.

Paper I made its contributions by introducing the concept of **Value Modes Effect & Analysis** (ValMEA), which presents a view regarding the interrelatedness of different definitions of value. One of the consequences is that *perceived customer value* needs to accommodate *life cycle cost* (LCC). This paper demonstrates that value measurements lead to the identification of improvement opportunities by integrating extended PCV measurements with the PI matrix. Improvement opportunities are product attributes that cause customer dissatisfaction and may be perceived as low value.
The contributions of paper II have been on the development of proactive quality cost measurements, which was derived from the dynamics of exchange value and perceived customer value. The proactive quality cost measurements provide connection to creative quality improvements and lead to an understanding that quality improvements subsequently influence the way customers perceive the value of a product.

Paper III is of value because it describes the transformation of the conceptual model of added value into a (complementary) performance measure for six sigma and lean production methodologies, which may better reflect the ultimate goal of these methodologies. The link between customer value in the market and in the production was first clarified and conceptualised before developing the metric.

Paper IV contributed by suggesting that improvement projects should be distinguished into proactive and reactive, to complement the existing big $Q$ and little $Q$ categorisation, as well as by developing value-oriented roadmaps and perceived-added-value algorithm for nominating and selecting both proactive and reactive improvement projects.

The contributions of Paper V are on the development of an algorithm to determine product attributes that are critical to quality (CTQs) based on received customer value (RCV) measurements and how to measure and monitor RCV over time. Prior to measurements, two issues regarding variation (i.e. variation regarding customer perceptions and variation regarding the way value is defined by producer and customers) and the implications were discussed from the perspective of system thinking.

7.3 Managerial implications

Considering that the aim of quality management is to create value to customers, it is important for producers (suppliers) to understand what the customers do value and that quality is essential for value creation. Managing quality towards value creation requires proactive thinking and action (based on highly credible data and/or information), meaning that managing quality is not just about product inspection or production control, but it concerns the company as a value-creating business.
The view on customer value requires the case company to expand the quality organisation by establishing a cross-functional group responsible for quality that works parallel with the existing quality function (that works mostly with quality in the manufacturing). At this stage, top management leadership and commitment play crucial roles. Managers in the organisation should also focus on long term goals (market and employees) besides on the short term goals (cost, productivity, delivery), because there is a tendency that managers perceive short term goals to be more important than the long term goals (market advantage and employees’ growth). The managers need to further explore the potential of customer value to improve organisational performance and employee contributions (as intellectual assets) on value creation.

7.4 Future research areas

7.4.1 Customer value in purchase and use contexts

The purpose of the research within this theme is to gain a deeper understanding of customer value by measuring customer value both in purchase and use contexts, where the impacts of *products, brands, services, relationships*, and *logistics* on customer value will be identified. The research will also study the purchase and use/consumption process from the perspective of customers in order to understand value creation through consumption.

The studies may provide answers to the following questions:
- Where and how the consumption process creates value to customers?
- To what extent would the customers of a company perceive the provided value as fair, high, or low?
- What are the characteristics of customer segments that perceive value as fair, high, or low?

7.4.2 Customer value and quality improvements

This research theme will further develop forward-looking quality management toward value-creation, where customer value is utilised as a basis to improve quality by answering the following questions:
- How does a company monitor performance in creating/delivering customer value?
• How does a company absorb and utilise the acquired information from customer value measurements in order to improve products and processes (i.e. the learning process and the improvement mechanism)?

The research will also investigate the effects of prevention and appraisal activities (in the improvements of product design) on forward-looking quality and the reduction of external failure costs and how quality improvements affect the customers’ perception of value. The prevention and appraisal activities may be extended to accommodate supplier relationships and supplier quality assurance.

7.4.3 Value-adding (-creating) processes/organisations

This category of research topic is strongly related with and intends to contribute to the development of TQM, Lean, and Six Sigma, where the research will measure added value in both manufacturing and non-manufacturing processes (i.e. service and public sectors), and benchmark the measurements between those two types of processes.

The added value measurements will also be conducted at an organisational level to benchmark the performance (efficiency) of these organisations. In this case, the “vehicles” such as quality awards and excellence models will become the basis of the evaluation. The result may give answers to questions regarding the prerequisites and the characteristics of value-adding (-creating) organisations.

In order to create value, organisations must be able to capture the dynamics of customer value. Hence, a system to capture the dynamics of customer value should be developed by integrating the information/knowledge of customers’ value perceptions and customer transaction data in order to support the company’s goal to be innovative and efficient (enable mass-customisation). The system integrates different functions in the company that play important roles in customer value creation (i.e. marketing, production, logistics, etc).
7.4.4 Interrelationship between customer (stakeholder) value and shareholder value

The research in this category will investigate the relationships among different “modes” of customer value as well as between customer value and shareholder value. The results of the research may provide analytical models that describe: 1) the relation between added value and customer value, and 2) the impact of customer value on shareholder value.

The research will also address the issue regarding the impact of value-creating leadership on employees’ ability to create value to customers.

7.4.5 Value-creating chain & network

Research in this category will investigate how a company or an organisation cooperates with other companies to create value to customers by forming a value-creating chain or network. The research is intended to find out the mechanism of a value-creating chain/network to: 1) responsively capture the dynamics of customers’ needs and demand, and 2) efficiently deliver those needs and demands.
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Customer value as a key performance indicator (KPI) and a key improvement indicator (KII)

Djoko Setijono and Jens J. Dahlgaard

Summary

Purpose – The purpose of the paper is to develop existing tools or methodologies to measure customer value during acquisition and use, in such a way that the measures concurrently indicate the level of performance and more “accurately” identify the improvement opportunities.

Design/methodology/approach – The producer is the entity that creates the products that the customers acquire or consume. This view makes the “general agreement” that customer value is nothing other than customer perception in the market no longer relevant. Therefore, ValMEA (Value Modes Effects and Analysis) offers a “balanced” perspective on customer value, by recognizing that customer value exists in different “modes” in different stages of the product’s life cycle. The link between different “modes” of customer value becomes an important basis to understand the contributions of producer activities on customer value.

Findings – Measuring customer value is necessary to capture the essential meaning of quality. However, the existing tools to measure customer value do not adequately manifest the concept of customer value itself. Therefore, the modification of these tools becomes the prerequisite to continuously improve quality performance. The measurement of customer value during acquisition and use is based on intangible aspects (cognitive judgement). Along the value stream, these measures are translated (transformed) into tangible aspects, which comprise aspects such as shorter lead-time, reduced defects, and lower costs.

Originality/value – The customer value measures complement the existing methodology such as Six Sigma, Lean Production, and Quality Function Deployment (QFD).

Keywords Customers, Quality

Introduction

Defining quality as fitness for use (Juran, 1962) rather than conformance to specifications implies an interpretation that products or services are meant to satisfy customer needs. It means that quality performance measures are no longer the monopoly of engineering in comparison with standards (i.e. product orientation) but they should also consider customer opinions (i.e. people orientation) since customers are the ultimate judges of quality (Garver, 2003). Therefore, Dahlgaard and Dahlgaard (2002) present the new TQM (Total Quality Management) metrology to measure quality from a customer perspective through satisfaction of both internal and external customers as well as other stakeholders. Relying only on customer satisfaction may not be sufficient; at least it is an implicit interpretation of the reason that TQM continues its evolution in search for a “new” quality definition. According to Aune (in Edvarsson and Gustafsson, 1999), quality is:

...maximum contribution to the health and happiness of all people involved in its production, use, destruction, and reuse. This with a minimum of total life cycle costs, assuming a minimum use of energy and other resources and with generally acceptable consequences for the society and environment at large.
This definition of quality consists of two important elements, i.e. contribution and cost. Contribution refers to what customers receive and cost refers to what customers and other stakeholders sacrifice. Summation or trade-off between what customers receive (e.g. benefits) and what they sacrifice (e.g. cost) determines customer value of a product or service (Bounds et al., 1994; Dumond, 2000). Nicholls (1993) states that the focus on customer value can be regarded as the fourth phase of the TQM evolution.

According to Juran (1951), the value of quality is a composite of value inherent in the design and value inherent in the conformance to that design. This means that improving design quality and conformance quality will likely increase value. A study in a Swedish wood-flooring manufacturing company indicates that about 80 percent of the total quality costs in the company are failure costs (both internal and external), and 20 percent is the sum of prevention and appraisal costs (Setijono, 2005). We may then perceive that there is a high amount of ‘waste’ (i.e. defects, non-conformities, inefficiencies, etc.) inside the company. The findings from interviews and observations conducted in the company suggest that external failure costs are mainly caused by not adequately considering the second and third customer tiers, i.e. the installers and end-users as shown in Figure 1. The manufacturer (M) fulfills a demand chain, which consists of three different types of customers, i.e. dealers (D), installers (I), and end-users (U). The dealers are the main or direct customers (first tier), while installers and end-users are the indirect customers. Since complaints regarding product quality are usually generated by these customers through the dealers or directly to the manufacturer (see Figure 2), while internal failures are mainly caused by a reactive way of managing quality and a lack of customer-supplier awareness inside the company. Therefore, there is a need to develop a framework to improve quality attributes that are valuable for customers, and which addresses both internal and external causes of quality-related problems.

Despite the fact that there are many different definitions about customer value, Higgins (1998) concludes that customer value and customer satisfaction are not disconnected. There are different models that attempt to describe the link between customer value and customer satisfaction, and even with other performance measures such as customer loyalty, profitability, and competitiveness. Most literature, especially in marketing, discuss the influence of customer value on purchasing decisions or discuss customer value in a service context. However, few discuss the influence of customer value in relation to the product in use context and how customer value may drive improvements of product and process quality. It is the aim of this paper to further develop the tools to measure customer value during acquisition and use, in such a way that the opportunities to improve product quality can be identified simultaneously.

![Figure 1](image1.png)  
**Figure 1** Supply and demand chain

![Figure 2](image2.png)  
**Figure 2** Complaint process
The paper is organized in the following structure: first, the author provides a brief theoretical review on customer value and customer satisfaction. Second, a “balanced” perspective on customer value is presented. Third, a “new” way of measuring customer value to indicate performance as well as to identify improvement opportunities is described. The author also gives an example of the application of the measures. The development of a customer-value-driven quality improvement framework is described thereafter. The paper then finishes with reflections and conclusions.

Theoretical background

Customer value

Any definition of value must account for the inclusion of total benefits, including direct and indirect benefits derived from attributes and consequences, that arise from partner (seller-buyer) activities and behaviours, less total direct and indirect costs, and be determined from the customer perspective (Simpson et al., 2001, p. 121).

Woodruff (1997; in Simpson et al., 2001) defines value as a customer’s perceived preference for and evaluation of those product attributes, attribute performances, and consequences arising from the use that facilitate (or block) achieving the customer’s goals and purposes in use situation. Dumond (2000) summarized the common themes about customer value that it is “linked to the use of product or service”, “perceived by the customers rather than objectively determined by seller”, and “usually involves a trade-off between what customer receives, e.g. quality, benefits, worth, and what he or she gives up to acquire and use a product or service, e.g. price, sacrifices”. Then, customer value is the summation of benefits minus the sacrifices that result as consequence of a customer using a product or service to meet certain needs. This definition moves away from the notion that value is something inherent to the product or service toward the notion that value is determined in the context of customer use (Bounds et al., 1994).

According to Khalifa (2004), the way of defining customer value can be grouped into three categories: value components model, utilitarian or benefits-costs ratio model, and means-ends model. In terms of the value components model, value is interpreted as the performance or physical characteristics of the product that:

- must-be present;
- are expected to be present; and
- delight the customers if the characteristics are present.

According to the utilitarian model, customer value is the difference (or ratio) between total benefits and total sacrifices. Value, according to the means-ends model, is the accomplishment of favorable ends through the acquisition and the use of a product as the means. Even though these models are (to some extent) different, they are not mutually exclusive but overlap with each other. This is utilized by Khalifa (2004) to build an integrative configuration of customer value concept by first “expanding” each basic category of customer value model.

Value map

The customer value map, introduced by Gale (1994), is a tool to analyze whether a product or a company has provided superior customer value by plotting market perceived quality (MPQ) against market perceived price (MPP) on a two-dimensional chart (see Figure 3). MPQ is the sum of multiplications between performance scores ratio (R) and importance weight (W) on each quality attribute, for example safety, durability, and availability. MPP is calculated as MPQ; the only difference is that MPP is applicable on price attributes such as purchase price, trade-in allowance, resale price, and interest rates. Performance and importance scores data are usually collected using surveys or interviews. Performance scores represent customers’ cognitive judgment on product attributes, measured by, e.g. a 1-7 scale, while the importance weight usually is
measured using a 0-100 scale, which represents how the various product attributes are weighted in the customer’s decision:

\[ MPQ = \sum_{i=1}^{n} R_i^* W_i \]  
\[ MPP = \sum_{j=1}^{m} R_j^* W_j \]

where:
- \( R_i \): the ratio between the performance score (\( P \)) of a product and the performance score of the competing product(s), on the quality attribute \( i \).
- \( W_i \): the weight (importance) of quality attribute \( i \).
- \( i \): 1, 2, 3, \ldots \( n \)
- \( R_j \): the ratio between the performance score (\( P \)) of a product and the performance score of the competing product(s), on the price attribute \( j \).
- \( W_j \): the weight (importance) of price attribute \( j \).
- \( j \): 1, 2, 3, \ldots \( m \)

Gale (1994, p. 83) illustrates the \textit{fair value zone}, i.e. the area where the ratio between MPQ and MPP is approximately 1. Within this zone, products or firms provide “fair” customer value, meaning that customers perceive a product with a certain quality level worth to be bought at its current price level. Outside this zone, a product or a firm provides more or less customer value (depending on the location of the point). A product or firm that provides better customer value is more competitive in the market compared to its competitors.

\textit{Performance-Importance (P-I) matrix}

Garver (2003) lists the use of the P-I matrix as a tool to: evaluate a firm’s competitive position in the market, to identify improvement opportunities, and to guide strategic planning. The P-I matrix utilizes customer satisfaction data, where for each product (or service) attribute, the average score of performance is plotted against the average importance score using a 2 × 2 matrix (see Figure 4). Actual performance is measured using, e.g. a 1-7 or a 1-5 scale, while relative performance can be measured by using gap analysis, comparative scales, or actual performance (Garver, 2003).

\textit{Value modes effects and analysis: a “balanced” perspective on customer value}

The statement “customer value, which is something that is determined in the context of customer use” refers to what is called received value. “Customer value, which is something that is perceived by customers rather than determined by the seller”, indicates that the...
customer already perceives the value of a product or a service during the acquisition (purchase) stage. Tracy and Wiersima (1995; in Khalifa, 2004) argue that the components of customer value include low price, speedy response, premium service, and high quality. These components of customer value are similar to what is labeled as “value added”, i.e. higher product or service quality, faster delivery, and lower cost, which are discussed within the manufacturing or production context by the concept of lean production, lean sigma, or lean thinking (see for example Antony et al., 2004; Wood, 2004), and Grönroos (2000; in Khalifa, 2004) who suggests that customer perceived value equals to core value + added value. The added value is positive when the additional services can be provided without unnecessary or unexpected costs, while it can be negative (and destroy the core value) when the contacts and processes in the customer relationship are not managed as services or when the additional services cause unnecessary (unexpected) costs.

The description above exposes the contradictions towards the “general agreement” about customer value in most literature or according to a majority of researchers (summarized by Khalifa, 2004), which suggest that customer value is determined by customers’ perception (in the market place) not by suppliers’ assumptions or intentions (in the factory). The “findings” suggest that producers or manufacturers give some effort to understand customer value and (in a large extent) being involved in the creation of customer value; therefore the “general agreement” should be challenged. It seems clear that the “raw” ingredients of customer value are high quality, faster response or delivery, and lower cost/price but it totally depends on the customers themselves to “transform” these raw ingredients into something valuable as well as to judge whether a product or service is valuable or not.

As an implication, customer value may exist in the following “modes”: added value, perceived value, and received value depending on which context the value is defined. Added value is the characteristics of high quality, faster delivery, and lower cost. Perceived value is a trade-off between benefits and sacrifices perceived by the customer in a supplier’s offering (Eggert and Ulaga, 2002) or customer’s overall assessment of the utility of a product based on the perceptions of what is received and what is given (Zeithaml et al., 1988; in Edvardsson and Gustafsson, 1999). Received value is the customer value in acquisition and use context (Horovitz, 2000; in Khalifa, 2004) and it is about customer’s experiences (Lanning, 1998; in Khalifa, 2004). According to Parasuraman et al. (1988; in Eggert and Ulaga, 2002), customer satisfaction is a feeling, the result of a comparison between perceived performance and one or more comparison standards, such as expectations.

It is difficult (if not impossible) to separate customer value and satisfaction. Therefore, customer satisfaction will always be in conjunction with customer value, either it becomes the predecessor of value (see Edvardsson and Gustafsson, 1999; Dumond, 2000; Khalifa, 2004) or the successor of the value (Oh, 1999; van der Haar et al., 2001; Dahlgaard and Dahlgaard, 2002; Eggert and Ulaga, 2002; Spitteri and Dion, 2004; Liu et al., 2005). In the purchase context and the service context, customer satisfaction becomes the successor of...
perceived value; while in the product use context, satisfaction is the predecessor of received value because the customer should be first “convinced” that the product has both the necessary and the additional characteristics as he/she expected before he/she believes that the product is the “right” means to achieve his/her ends (goals). Figure 5 provides a conceptual link of how added value (in manufacturing) turns to value received by customers. This link makes ValMEA (Value Modes Effects and Analysis) consistent with the existing theory about customer value that the “… categories of value definitions are not mutually exclusive” (Khalifa, 2004; p. 648).

Perceived value, customer satisfaction, and received value are the “representation” of value during acquisition (purchase) and use. These “representations” of value accommodate the three models to categorize customer value definitions (i.e. value components model, utilitarian model, and means-ends model) and explain the fundamental difference between them. The term value in the means-ends model refers to a cognitive judgment (about the accomplishment of a goal), while the same term refers to a feeling (of satisfaction) and an assumption (that the benefits are more than the sacrifices), according to the value components model and the utilitarian model respectively. In this respect, the definitions of customer value are based on intangible aspects, i.e. perception. This perception is then understood and transformed into tangible attributes, such as quality (the function, the fit, and the form), that are built into a product (at a lower costs and shorter time) in order to help customers accomplish their goals. The interpretation (transformation) of customer value from being intangible to be tangible makes ValMEA a more “balanced” perspective, in the sense that the contributions and involvement of the producer into the creation of customer value are also recognized.

The effect-and-analysis part of ValMEA can be explained through the following interpretations. The received value is the “ultimate” value for the users, where the acquisition and ownership of a product fulfilled their goals. Therefore, information about received value become crucial inputs for the producers to improve product quality. Perceived value is important for the manufacturers in order to satisfy the needs of their customers (end users or resellers) by increasing the performance of their product or service quality. Added value becomes an enabler to the creation of customer value, where quality is one of the essential elements. If quality is such an important component of customer value, then “how should we define quality so that it reflects the concept of customer value?”. The following reflection should be regarded as an attempt to answer the question. Quality is the degree of existence (dissatisfactory, satisfactory, or delight) of product or service attributes which are considered (perceived or judged) as valuable (facilitate the accomplishment of goals) and which are attainable at a fair cost.

Measuring customer value during acquisition and use

Perceived customer value is the “representation” of customer value during the acquisition, which can be measured using the customer value map. However, Gale (1994) does not further discuss the way to determine the zone of fairness, i.e. the zone where the customers perceive a fairness or balance between the quality (benefits) and price (sacrifice). Therefore, the fair value zone must first be determined. Additionally, the value map mainly highlights customer value as a factor that influences purchasing decisions and not customer value in a use-context. However, by “extending” the term “price” to “life cycle cost”, it can be argued that the customer value map is also applicable in a use-context.

Figure 5  Links between added value and received value
The value map is useful to indicate:

- whether the value of a product is perceived as “superior” or “inferior” compared to other competing products; and
- if the value of an individual product is perceived as fair, low value, or high value.

However, the value map is inadequate to indicate what product attributes must be improved to enhance the value provided to the customers. Therefore, the value map should be combined with a performance-importance (P-I) matrix to identify improvement opportunities, so that the product (quality) attributes that cause the “inferiority” on customer value can be identified. The “problem” is, the “as it is” P-I matrix, do not adequately accommodate the concept of customer value. We then need to modify the existing P-I matrix by accommodating a value components model, such as the Kano model (Kano, 2001).

**Determining the zone of customer value fairness**

According to Monroe (1990; in Padula and Busacca, 2005), the value of a product comprises acquisition value (AV) and exchange value (EV). Acquisition value is about customer’s perception of what he/she “gets” and “gives”. The acquisition value is more popular under the “label” perceived customer value (PCV), where PCV is defined as the ratio between Market Perceived Quality (MPQ) and Market Perceived Price (MPP). Then:

\[
PCV = \frac{MPQ}{MPP}
\]

(3)

The exchange value represents the perceived merit of the offer or deal (Monroe, 1990; in Padula and Busacca, 2005), which manifests in the form of price, \( P \) (Padula and Busacca, 2005). Therefore:

\[
EV = P
\]

(4)

Then, the zone of fairness can be derived mathematically by assuming that:

- the value exchanged by a customer is equal to the value that he/she gets in return (acquired); and
- a product with higher product quality can be sold at a higher price.

Based on the first assumption, we may then define the following equation:

\[
PCV = EV
\]

(5)

Without a modification, this equation will be difficult to implement because PCV and EV have different unit of measurements, in which PCV is dimensionless while EV is stated by a currency, e.g. $, £, etc. To solve the problem, the price, as the manifestation of exchange value, should be conceptualized as a multidimensional construct rather than a one-dimensional construct (Padula and Busacca, 2005), which means that the customers evaluate actual price in comparison with the utility (U) of a product (either in a subjective or relative way). In a subjective price evaluation, utility is defined as the willingness to pay, where the customers might be willing to pay more or less than the price expected by the seller. In case of relative price evaluation, utility is defined as the worth of the product, which represents customers’ judgement of the fair price to acquire a product. The price that is considered as fair might be equal or less than the actual price offered. In both cases, utility is dependent on customer’s judgment about the product he/she acquired. The customers might judge the quality of the product (in comparison with other competing products) to determine the utility (worth) of a product (Mochimoto and Ohfuji, 2005). Then, the multidimensional conceptualization of price requires us to reformulate equation 5 into:

\[
EV = \frac{U}{P}
\]

(6)

If utility is defined as “willingness to pay”, the ratio between utility and actual price can be between zero (0) and positive-indefinite (+∞). However, when utility is defined as “worth”, the ratio between utility and the actual price will be between 0 and 1 because the relative
utility assumes that the actual price is assumed as the maximum amount of money that the customers are willing to pay. Therefore, the second assumption allows that customer’s willingness to pay can be less or more than actual price.

If we compare equation 3 and equation 6, it seems that we can verify the first assumption (i.e. the equality between acquisition value and exchange value), due to the convergence in the meanings of utility. In the field of economics, utility is defined as the satisfaction due to the consumption of products, which is quite similar in the field of quality management, where utility reflects the ability of a product to satisfy users or customers. This ability depends on the function, fit, and form of the product. The customers’ judgment on these aspects determines the way customers perceive the quality of the product.

The zone of fairness may be determined with the help of the data described in Gale (1994, p. 304), where the data about market perceived quality (MPQ) of different companies have been collected and stored in the PIMS database (Profit Impact of Market Strategy). Gale’s classification suggested that if firms are categorized as “about the same quality”, the market perceived quality lies between 0.92 and 1.08. The selling price of the product from these firms varies within the range of 0.97 to 1.04 of the current price level.

We are then able to determine that $0.92 \leq MPQ \leq 1.08$ and $0.97 \leq \frac{U}{P} \leq 1.04$. While the MPP is estimated using the following equation:

$$MPP = \frac{MPQ}{\frac{U}{P}} = MPQ * \frac{P}{U}$$  

(7)

where the result is shown in Table I.

The zone of satisfaction is the distance between the upper value line and the lower value line, where the equations for these lines are shown in Table II. In other words, the zone of satisfaction is actually the total “distance” between MPQ and MPP on the lower and upper sides, but for the purpose of simplification, the distance between MPQ and MPP for each side is assumed to be equal. Therefore, the zone of fairness may then be defined as the interval within $y = x \pm 0.03$.

### Life cycle costing (LCC) and “Customer Cognitive Judgement” (CCJ)

ValMEA recognizes the difference between perceived and received value. This makes the ordinary value map, suggested by Gale (1994), inadequate to accommodate and capture the received value in a use-context. Therefore, the author suggests that the price-related attributes should be extended into life cycle cost (LCC) related attributes, and recommend the use of “Customer Cognitive Judgement” (CCJ) in order to distinguish from the term “Market Perceived” (MP) introduced by Gale.

<table>
<thead>
<tr>
<th>MPQ</th>
<th>$\frac{U}{P}$</th>
<th>MPP</th>
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<tbody>
<tr>
<td>0.92</td>
<td>0.97</td>
<td>0.95</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1.08</td>
<td>1.04</td>
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<table>
<thead>
<tr>
<th>MPQ (x-axis)</th>
<th>MPP (y-axis)</th>
<th>Equation</th>
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<tbody>
<tr>
<td>Upper value line</td>
<td>0.92</td>
<td>0.95</td>
</tr>
<tr>
<td>Line of fair value</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Lower value line</td>
<td>1.08</td>
<td>1.04</td>
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The new definition of quality (Aune op cit) refers to the importance of minimum life cycle costing (LCC), which includes the cost of ownership during the lifetime of a product. The concept of LCC becomes important when customer value is identified not only in a purchase-context but also in a use-context. It also becomes critical for a manufacturer when market competition includes both competitor and substitute products.

Taking wood flooring products as an example, the manufacturer of wood flooring products is facing market competition from other wood flooring products as well as substitute products such as laminate floors, carpets, and plastic floors. A study by Moussatche and Languell (2001) shows that the LCC of wood-based flooring materials is significantly higher than other flooring materials, and the difference is mainly caused by high costs after the purchase (acquisition) of the product.

There are several LCC models, which are categorized either as general or specific, according to products or industry types (Dhillon, 1989). One of those models describes LCC as the sum of price, installation cost, operation & maintenance cost, and disposal cost.

Value-driven P-I matrix

It is assumed that a quality attribute satisfies the customer if customer’s perception is greater or at least equal to expectations. In the P-I matrix, this perception is represented by the “performance” (P) axis and the expectation is represented by the “importance” (I) axis. Performance is the level of satisfaction of quality attributes, while Importance is the significance of the quality attributes of the product or the presence of characteristics. Therefore, the P-I matrix (which actually is another form of a gap analysis tool) can be used as a tool to analyze customer satisfaction on the various product quality attributes.

According to Khalifa (2004), the Kano model (Kano, 2001) is a well-known value components model, which includes three components of value: dissatisfiers (must be), satisfiers (more is better), and delighters (exciters). Therefore, customer satisfaction seems to be an important indication whether the customers, during the use of a product, regard the attributes of a product as valuable or not.

Using merely the P-I matrix as a customer satisfaction analysis tool does not seem to fulfill the condition that satisfaction is linked to value. However, because the P-I matrix does not recognize the zone of satisfaction (see Figure 6), an area or interval on the P-I matrix where product attributes can be categorized as satisfiers. This area is analogue to the zone of fairness (in the value map), if we define “fairness” as the absence of gap between performance and importance. Hence, satisfaction is a condition where the difference between P and I is equal or near to 0. Outside this zone of satisfaction, product attributes are categorized as delighters if their performance is larger than their importance, while these attributes are dissatisfiers for the customers if the performance is lower than the importance.

Figure 6 P-I matrix incorporating value components model
The use of cells in order to indicate improvement opportunities is not quite accurate because it “neglects” the “zone of fairness”, where the “performance” is approximately at the same level as “importance”. Therefore, value components should be incorporated into the P-I matrix, and after determining the zone of satisfaction, the attributes which need to be improved can be identified.

Assuming that the product (quality) attributes are independent of each other, the zone of satisfaction (ZOS) may be determined in a similar way as the control limits of a control chart, where inside the zone of satisfaction, the difference between the performance and importance of product attributes is regarded as random variation. The exact value of this difference varies for each attribute, but still “within its natural variation”. Hence, ZOS is calculated as plus/minus three times its standard deviations.

For each of quality attributes, the average difference \( D \) between performance score \( P \) and the importance score \( I \) can be further defined as:

\[
D_j = P_j - I_j = \frac{1}{n} \sum_{i=1}^{n} \frac{P_i}{n} - \frac{1}{n} \sum_{i=1}^{n} \frac{I_i}{n}
\]

where:

- \( D_j \): The difference between the performance score and importance score of quality attribute \( j \).
- \( P_j \): The average performance score of product (quality) attribute \( j \).
- \( I_j \): The average importance score of product (quality) attribute \( j \).
- \( m \): The total number of quality attributes.
- \( P_i \): The performance score of a certain product attribute, which is given by customer \( i \).
- \( I_i \): The importance score of a certain product attribute according to customer \( i \).
- \( n \): The total number of customers.

The construction of the control chart to plot multiple quality attributes is based on the assumption that if the values produced and delivered are in balance with expectations then the average difference \( D \) (between performance and importance) of each quality attribute is equal to zero. The centre line of the control chart is under the same assumption also equal to zero. The upper limit of ZOS (ZOS\text{upper}) and the lower limit of ZOS (ZOS\text{lower}) of the control chart can then be determined as:

\[
ZOS_{\text{upper}} = 3\sigma
\]

\[
ZOS_{\text{lower}} = -3\sigma
\]

We may estimate \( \sigma \) by calculating \( s \), where:

\[
s = \sqrt{\frac{\sum_{j=1}^{m} (D_j - D)^2}{n(m-1)}}
\]

In which:

\[
D = \frac{\sum_{j=1}^{m} D_j}{m}
\]

Incorporating these value components into the PI matrix shows that quality improvement opportunities are no longer indicated by a “major weakness” cell but showed by the area of dissatisfaction. The area of dissatisfaction can be further categorized into major or minor priority (see Figure 7).

Adopting the control chart principles should also take into consideration the fact that a certain quality attribute might have different impact on different customers or customer
segments, in the sense that a quality attribute may dissatisfy one customer (segment) but may delight another. Therefore, the construction of the control limits in (9) and (10) should be complemented by a control chart to control the individual customer satisfaction measurements on each of the \( m \) quality attributes. The center line in this control chart is also equal to zero but \( s \) is here estimated by (13) below:

\[
  s = \sqrt{\frac{\sum_{i=1}^{n} \sum_{j=1}^{m} (D_{ij} - D_{i})^2}{m' (n - 1)}} \tag{13}
\]

where:

\( D_{ij} \): The difference between the performance score and the importance score on quality attribute \( j \) given by customer \( i \)

**Example of application**

Let’s assume that there are two competing products in a certain market segment, product A and product B. There are \( n_1 \) (let \( n_1 = 100 \)) customers of product A and \( n_2 \) (let \( n_2 = n_2 \)) customers of product B whom were asked about the importance and performance of each product attribute, i.e. quality attributes \( (Q_1, Q_2, \ldots) \) and cost attributes \( (C_1, C_2, \ldots) \), e.g. price, operational and maintenance cost, of each product and their responses are measured using a 1-7 scale (7 is the maximum on the scale). Prior to data collection, it is necessary to have an “agreement” on what a low or high measurement scale may indicate. For example: a low importance score on a product (or quality) attribute might indicate that this attribute is less or not important. A similar condition (low importance) in a cost attribute might be interpreted as that it is less or not important whether a certain cost attribute has a low cost or not. A low performance score on a product (quality) attribute can be used to indicate a poor performance as well as that a certain cost attribute is expensive. The average importance and performance scores for both product A and B is recorded in Table III.

The next step is to calculate customer value of each product. In this case, the importance weight is determined from importance scores. The importance weight of the \( j \)-th attribute \( (W_j) \) is determined by the ratio between the \( j \)-th normalized importance score \( (I_{norm}(j)) \) and total normalized importance score. The normalization process, which is analogue to the normalization procedure as described in, e.g. Antony (2000) and Best (2004), is expected to reduce the dependence on the measurement scale, so the results are comparable either we use a 1-7 scale or a 1-10 scale. Equation (14) shows the calculation of the normalized importance score of the \( j \)-th attribute, where \( I_j \) is the importance score of the \( j \)-th attribute from each product, is the maximum (highest) importance score and is the minimum (lowest)
importance score. Since we are using a 1-7 scale, then and is 7 and 1 respectively. Table IV shows the way of determining the importance weight of each product attribute:

$$I_{norm}(j) = \frac{I_j - I_{min}}{I_{max} - I_{min}}$$  \hspace{1cm} (14)

Table V shows the score of customer cognitive judgment regarding quality and cost of product A, where R is the ratio between the performance of product A relative to the performance of product B on quality or cost attributes. The customer cognitive judgment on quality (CCJQ) or customer cognitive judgment on cost (CCJC) of product A is the sum of multiplications between the importance weight (W) and the performance of product A relative to product B (R) on the j-th quality-related or cost-related attribute. The CCJQ and CCJC for product B or firm Y is shown in Table VI but in this case we use 1/R to indicate the performance of product B relative to product A.

The CCJQ for each product or firm is then plotted against its CCJC in order to identify the product or firm performance in providing customer value. Figure 8 provides a visualisation of the competitive position of each product in providing customer value. It indicates that

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<th>Importance B</th>
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<tr>
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<tr>
<td>Q2</td>
<td>0.780</td>
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<td>1.560</td>
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</tr>
<tr>
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<td>1.095</td>
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<tr>
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<tr>
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<td>0.190</td>
</tr>
<tr>
<td>Total</td>
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product B provides better customer value and product A provides worse customer value, which means that product B gives more “value for money”. If product A and B are produced by different companies, then we may perceive that the manufacturer of product B is more competitive than the manufacturer of product A.

**Identifying improvement opportunities**

Customer value can be increased through (product) quality improvement or alternatively through cost reduction. Considering that improving quality may also lead to cost reduction, then quality improvement is a *must-be* need to increase customer value. Improving quality proactively requires an identification of improvement opportunities through, in this case, customer satisfaction analysis. Then, the next step after analyzing the customer value is to analyze customer satisfaction using the control chart of multiple quality attributes (by plotting the average difference between performance and importance score for each attribute) or using P-I matrix in order to identify the quality improvement opportunities, which is performed by plotting the performance score on the selected quality attributes of a product against its importance score. Although it is possible to analyze the performance and importance of the attributes of both product A and B, this paper will only describe the

<table>
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<tr>
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</tr>
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<td>Q4</td>
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<tr>
<td>Q5</td>
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<td>Q6</td>
<td>0.072</td>
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<tr>
<td>Q7</td>
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<tr>
<td>Q8</td>
<td>0.093</td>
</tr>
<tr>
<td>Q9</td>
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</tr>
<tr>
<td>Q10</td>
<td>0.092</td>
</tr>
<tr>
<td>C1</td>
<td>0.114</td>
</tr>
<tr>
<td>C2</td>
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</tr>
<tr>
<td>C3</td>
<td>0.281</td>
</tr>
<tr>
<td>C4</td>
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</tr>
<tr>
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<table>
<thead>
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<tr>
<td>Attribute</td>
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<td>Q5</td>
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<td>Q6</td>
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<td>Q7</td>
<td>0.131</td>
</tr>
<tr>
<td>Q8</td>
<td>0.093</td>
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<td>Q9</td>
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<td>Q10</td>
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<tr>
<td>C1</td>
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</tr>
<tr>
<td>C2</td>
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<tr>
<td>C3</td>
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<td>0.216</td>
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<td>1.021</td>
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<td>CCJC</td>
</tr>
<tr>
<td></td>
<td>0.996</td>
</tr>
</tbody>
</table>
customer satisfaction analysis of product A, mainly due to a consideration that the customer value provided by product A has been judged as lower than the customer value provided by product B.

We first need to calculate the difference between performance and importance for each attribute (\(D_j\)) according to equation 8, and then calculate the average and the standard deviation before we can define the control limits. Table VII shows the calculation of \(D_j\).

Using equation (12) and (11), we estimate that the value of D and \(s\) are 0.263 and 0.064 respectively. Then, based on equation (9) and (10), we could construct a control chart for multiple quality attributes, where the UCL = 0.1915 and the LCL = −0.1915, which is shown graphically by Figure 9. It is also possible to analyse the customer satisfaction using \(P-I\) matrix, by plotting the importance score of an attribute against its performance score (see Figure 10). Both the control chart and the \(P-I\) matrix indicate that there are several attributes outside control limits or zone of fairness respectively. The quality attributes Q1, Q3, Q5, Q6, Q9, and Q10 are the delighters, while Q8 seems to be a satisfier. Since the performance of attribute Q2, Q4, and Q7 are lower than their importance, then these attributes should immediately be improved. When further analyzing these attributes it may be good help to use the control chart for the individual customer measurements. For this purpose, (13) is used to estimate \(s\) in (9) and (10).

Hence, it is obvious that the value map can be used in conjunction with the modified \(P-I\) matrix and/or the control chart for multiple quality attributes. However, for a thorough

<table>
<thead>
<tr>
<th>Attribute</th>
<th>(D_j)</th>
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<td>Q4</td>
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<td>Q9</td>
<td>0.71</td>
</tr>
<tr>
<td>Q10</td>
<td>0.46</td>
</tr>
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</table>
analysis, it would be beneficial to complement the value map and the P-I matrix with a complaint report in order to provide more “evidence” or “confirmation” for the decision to improve quality attribute Q2, Q4, and Q7. The next step is to track, analyze, and improve the process that is related with these attributes. Internal defect reports and identification of inefficiencies will support the process and production improvements.

Customer-value-driven quality improvement framework

The framework of quality improvement (Figure 11) starts with an assessment of the product’s competitiveness in providing customer value relative to competition (and eventually substitute products), using a Value Map. The next step is to identify which product attributes need to be improved. The firm might also complement (or “confirm”) the findings with
complaint data from external customers and internal data regarding defects. Next, trace to the processes that are “responsible” for the quality attributes. During production, the inefficiencies (e.g. delays) occurred also deserve attention for improvement efforts.

In Figure 11, it can be recognized that customer value has a direct influence on product quality improvement and deployed further to process and production (see vertical arrow). Performing quality improvement in this way recognizes and increases the benefits of using improvement tools like Quality Function Deployment (QFD). By integrating the customer value map and the P-I matrix (or D-chart) into QFD, the customer voices can be captured repetitively, which then becomes a manner of continuous improvement. Meanwhile, continuous improvement can also be undertaken by identifying and eliminating waste in internal operation (see horizontal arrow) using for example the Lean (Six) Sigma method. According to George et al. (2004), Lean (Six) Sigma is a powerful improvement methodology, which combines the strengths or advantages of Six Sigma (see, for example, Antony et al., 2004) and the lean concept (see, for example, Wood, 2004) to improve both quality and process flow (speed). Through its four keys (i.e. delighting customers with quality and speed, process improvement, teamwork, and decisions based on data and facts), Lean Sigma becomes a way for manufacturers in providing customer value.

Conclusions
Calculation of customer value is not merely a way to indicate a company’s competitive advantage relative to competitors but it may also become a driving factor to continuously improve product and process quality. Customer value may drive continuous improvement of product and process quality because it exists in several modes (i.e. added value, perceived value, and received value), which is due to the fact that customer value occurs in several contexts and the term “customer” usually refers to a heterogeneous groups of people (market segments) and sometimes involves several customer tiers (e.g. dealers, service
providers, and end users). Identifying customer value (in a purchase/use and manufacturing contexts) lead to both reactive and proactive improvements. These two types of improvements are not mutually exclusive but complement each other in order to construct a customer-value-driven quality improvement framework.

The customer-value-driven quality improvement framework integrates the tools to identify customer value (Value Map) and customer satisfaction (Performance-Importance (P-I) Matrix or D-chart) with the existing methodologies in managing quality, in this case QFD and Lean Six Sigma. Due to the existence of value in different modes (ValMEA), the ordinary value map and P-I matrix need modification, as suggested in this paper, in order to better capture the essence of customer value to drive quality improvements.

References


Further reading


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The Value of Quality Improvements

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Abstract

Purpose - To present a proactive quality costs measurement methodology, which describes the value of quality improvements and the implication of this value on customers' perception regarding the value of the product.

Design/methodology/approach - By describing the perceived customer value in a dynamic term, it becomes possible to derive an analytical model that recognizes the implication of a company's efforts to improve design quality and conformance quality on product value as perceived by the customers. Quality costs as a performance indicator of improved design quality and conformance quality (as the results of prevention and appraisal activities) can be expressed in terms of value (i.e. a trade-off between benefits and sacrifices), where the benefits of the improvement include higher product quality and reduction of failure costs. The sacrifices include the costs to perform improvement activities (i.e. prevention and appraisal costs). Expressing quality costs in this way thus establishes a link between producer's efforts to improve quality and the way customers perceive the value of the product. The developed methodology of proactive quality cost measurement has been applied for collecting, measuring, and reporting quality costs in a Swedish wood-flooring manufacturing company.

Findings - Transforming quality cost measurements into value provides a better explanation regarding the effect of prevention and appraisal activities on the quality improvement indicators. Thus, the value of quality improvements is a measure of return on quality improvements (ROQI), which indicates whether the quality improvement efforts gave higher, fair, or lower return.

Originality/value - This paper develops and discusses a model of customer value by accommodating its relative-nature, and presents a proactive way of measuring quality costs (i.e. value-oriented and customer-oriented).

Keywords Proactive quality cost, value, return on quality improvements.

Paper type Research paper.

Introduction

Quality cost is a well-known concept in the area of quality management and gains much attention from the academic society as well as companies, consultants, etc. However, most of the authors discuss the subject of defining and categorizing quality cost but skip over the subject of gathering/measuring (Williams et al, 1999; Mandal and Shah, 2002). In practice, few companies have established systems for collecting the required cost elements, which probably is caused by a lack of systematic methodologies for collection, measurement, and reporting (Shah and Fitzroy, 1998).
The existing concept of quality costs itself has been criticized as: 1) it is reactive rather than proactive, i.e. deals with the consequences of failures and losses, 2) it is based on producer's way of defining quality and it does not adequately take customers' perspectives into account (Moen, 1998). Gryna (1977; in Juran, 1998) tried to solve problem (2) through the development of a user's quality cost definition, but was criticised that it was still reactively defined.

Roden and Dale (2000) state that the value of conducting a quality cost analysis is through highlighting non-value adding activities or waste and pinpointing potential improvements. According to Dahlgaard et al (1992), quality costs are an indicator (or a measure) of the effectiveness of a quality management system, and the identification of potential failures lead to the identification of improvement opportunities. Conti (1993) states that using only quality costs for improvement is inadequate; it is necessary to broaden the narrow perspective of quality costs into a customer value analysis to capture a broader impact of quality and adopt a continuous improvement approach to "sense" the improvement opportunities.

We may capture the messages above that: 1) there is a need for a systematic quality cost collection, measurement, and reporting system, as well as 2) there is a need to develop quality cost measurements in a proactive way, i.e. to consider the customer's perspective, which often either may be difficult to measure or is unknown. Hence, the purpose of this paper is to suggest a proactive quality cost measurement methodology as a mechanism to indicate if quality improvements are valuable in the sense that the producer's efforts (activities) to improve quality will likely affect customers' perceptions about the value of the product. Thus, it encourages awareness that producers have active roles (e.g. capturing, interpreting, and improving) in customer value creation.

After a literature review, the authors present a model of dynamic customer value and the producer's way of viewing and influencing customer value, followed by the description of a methodology for systematically collecting, measuring, and reporting quality costs. Next, the paper presents a case study in a Swedish wood-flooring manufacturer, where quality costs were identified and measured using the new methodology, and the applicability of proactive quality cost measurements. After discussion of the results and the findings, the authors finalise with conclusions.

**Literature review on quality cost**

*Definitions of quality cost*

Juran (1951; in Dahlgaard, 1998) first defined quality cost as the *cost, which would disappear if no defects were produced*. This definition was redefined, by Juran after 38 years, as the *cost of poor quality is the sum of all cost that would disappear if there were no quality problems*. According to Besterfield (1994; in Chiadamrong, 2003), quality costs are those *costs associated with the non-achievement of product or service quality as defined by the requirements established by the company and its contract with customers and society*. All these definitions view quality cost as the consequence of failures or problems.

A “wider” interpretation of quality cost can be found in the definition that quality cost is the *cost in ensuring and assuring quality as well as loss incurred when quality...*
is not achieved - BS 6143 part 2 (see e.g. Dale and Plunkett, 1999) or the expenditure incurred in defect prevention and appraisal activities plus the losses due to internal and external failure - BS 4778 part 2 (see e.g. Dale and Plunkett, 1999).

Campanella (1990; in Dahlgaard et al, 1998) presented another version of quality cost as the sum of prevention, appraisal, and failure costs that represents the difference between the actual cost of a product or service, and what the reduced cost would be if there was no possibility of substandard service, failure of product, or defects in their manufacture.

The definition of quality cost in Kolarik (1995) is probably the most appropriate to “integrate” the different definitions above. Kolarik defines quality cost as any cost that result from the fact that systems (including people), processes, products, and services are imperfect.

Models and definitions of quality cost elements
According to Feigenbaum (1956, 1991), quality costs include two principal areas, i.e. the cost of control and the costs of failure of control. The costs of control are measured in two segments: prevention costs and appraisal costs, and the costs of failure of control consist of internal failure costs and external failure costs.

Prevention cost is the cost or investment of any action taken to investigate, prevent, or reduce the risk of non-conformity (BS 6143 part 2, in Dale and Plunkett, 1999) or errors from occurring in all functions within the company (Omachonu et al, 1994). Prevention cost reflects the upfront investment of time and effort to prevent a problem from occurring (Millar, 1999); it seeks to eliminate the opportunity for quality defects (Angell and Chandra, 2001).

Appraisal cost is the cost of evaluating the achievement of quality requirements including e.g. cost of verification and control performed at any stage of the quality loop (BS 6143: part 2) whenever there exists a chance for poor quality (Angell and Chandra, 2001) incurred before shipment of the product (Omachonu, 2004).

Internal failure cost is the cost arising within an organization due to non-conformities at any stage of the quality loop such as costs of scrap, rework, retest, re-inspection, and redesign (BS 6143: part 2, in Dale and Plunkett, 1999; Morse, 1993; in Angell and Chandra, 2001). It is the result of quality failures or defective goods found within the company before shipment to customers (Millar, 1999; Angell and Chandra, 2001; Omachonu, 2004).

External failure cost is the cost arising after delivery to customers/users due to non-conformities or defects which may include the cost of claims against warranty, replacement and consequential losses and evaluation of penalties required (BS 6143: part 2, in Dale and Plunkett, 1999). It is the cost resulting from products not conforming to customer requirements (Millar, 1999) or cost associated with defects that are found after the products are shipped to the customers (Angell and Chandra, 2001; Omachonu, 2004).

Several authors have proposed models of quality cost, e.g. Dahlgaard et al (1992) and Dahlgaard et al (1998) suggest that quality cost can be classified in two
dimensions, with internal and external quality costs on the one dimension and visible and invisible quality costs on the other dimension; Sandoval-Chavez and Beruvides (1998) add opportunity cost into the PAF (Prevention-Appraisal-Failures) model; Chiadamrong et al (2003) propose that total quality cost is the sum of production-invisible quality costs, visible quality costs, and opportunity cost. Other models such as time-based cost element method and semi-structured identification and measurement methods, i.e. department based quality cost analysis method, team-based quality cost analysis, and a process cost model have been described in Dale and Plunkett (1999).

Carr and Ponomeon (1994; in Omachonu et al, 2004) suggest that internal failure is the most expensive and prevention is the least expensive quality cost component. Omachonu et al (2004) suggest that prevention activities have a direct and positive influence on the profit margin and the company should not exclusively invest in appraisal because it may lead to unacceptable costs and may affect the company's reputation. The failure costs are usually much higher than prevention and appraisal costs, and failure costs have a negative correlation with the level of quality.

Tsai (1998) "initiates" the effort of identifying the link between quality cost and value by classifying the quality cost elements into "value-added" and "non value-added" based on Activity Based Costing (ABC). Although the model indicates value added (-ness), there is no reference to customer value neither the effect of those value-added (-ness) on customer value. He also highlights that the PAF and the ABC models are related, where prevention and appraisal costs are value-added quality costs and failure costs are non-value added quality costs.

The use of quality cost
Quality cost can be used to capture top management’s attention for quality programs (Angell and Chandra, 2001) to indicate the quality level (Chen and Weng, 2002) and the symptom of problems (Millar, 1999). It is an important aspect of the development of a quality system (Dahlgaard et al, 1992) and a foundation for building a quality culture and implementing TQM as well as sophisticating the quality culture and management in term of practices (Prickett and Rapley, 2001; Mandal and Shah, 2002). The use of quality cost usually leads to the identification, selection, priority, measurement, evaluation, and monitoring of quality improvements (Keogh et al, 1998; Dale and Plunkett, 1999; Williams et al, 1999; Angell and Chandra, 2001), which is found to be very beneficial for continual improvement at the beginning of a quality journey (Tatikonda and Tatikonda, 1996; in Angell and Chandra, 2001).

According to Dale and Plunkett (1999), quality cost is a business parameter and a performance measure that can be used as a means for planning and controlling future quality costs (see also the "quality cost thermometer", implemented in Milliken Denmark A/S (in Dahlgaard et al, 1998)). Omachonu et al (2004) state that a quality cost system can be established in an attempt to increase the value of the product and process output, and enhance customer satisfaction.

Juran (1951) states that the purpose of quality management is to satisfy customer requirements through quality of design and quality of production (conformance to specifications), or similar to Ishikawa's forward-looking and backward-looking quality (see Kondo, 1993). The existing concept of quality costs is very much
influenced by conformance quality or backward-looking (must-be) quality but is less influenced by design quality or forward-looking (attractive) quality. Hence, quality costs depend on how the quality is defined and who (producer or customer) defines it. Therefore, quality cost normally presents a measure seen from the producer's perspective but seldom from the customer's perspective.

In order to capture the "true essence" of quality, it is suggested that quality costs should be put in another context and measured in a new way, i.e. in terms of value. By doing so, the measurements can be used to model the contribution of improvements on the change in customer value.

Customer value and its dynamic model

Customer value
Customer value is a trade-off (in terms of a difference or a ratio) between benefits and sacrifices (Dumond, 2000; Khalifa, 2004). The customers may be willing to sacrifice a certain amount of time, effort, money, and risk in exchange of expected benefits such as utility value and/or psychic value (Khalifa, 2004). When the benefits are expected to be higher than the sacrifices, then the customers may decide to purchase the product.

According to Bounds et al (1994), customer value is both idiosyncratic (personally determined) and relative (changing over time). Most of the models that explain the concept and definition of customer value emphasize the idiosyncratic nature of customer value but there is not much emphasis on the relative nature because accommodating the relative nature of customer value into a model is not a simple task. The idiosyncratic and relative natures make customer value subjective, ambiguous, and difficult to define (Khalifa, 2004).

A dynamic model of customer value
In this paper, a model to accommodate the relative nature of customer value is proposed, with the assumptions that: 1) the model is to be used to describe the effect of continuous improvements on customer value, and 2) the main focus is on customer value in the acquisition context, or as Gale (1994) refers as perceived customer value, which is defined as a ratio between market perceived quality (MPQ) and market perceived price (MPP).

The dynamic model of perceived customer value (PCV) can be expressed as:

$$PCV_{i+1} = PCV_i \cdot R_{PCV}$$

Where:
PCV$_i$ : Perceived customer value at time $i$

R$_{PCV}$ : The relative change in PCV from time $i$ to ($i+1$), stated as $\frac{PCV_{i+1}}{PCV_i}$

Customer value is indeed changing over time, and people's perceptions about the value of a product can only be measured at a certain point in time. Since customer value is also idiosyncratic in its nature, the customer is the only entity that knows exactly the way he/she perceives the value of a product. Other entities, such as the producer, can only estimate (approximate) customers' minds (perceptions) regarding
the value of a product. However, producer's activities have significant effects on customers' perceptions regarding the value of the product. In the following sections, the producer's way of viewing and influencing customer value will be discussed and defined.

Producer's view (interpretation) of customer perceived value

The producer may face another difficulty on the attempt to predict the PCV because the PCV is an abstract (intangible) matter and may be difficult to understand. According to Conti (2005), an economic relation (i.e. the relation between seller and purchaser in the purchasing-context) always implies the relation between the purchaser and the "object" of transaction (product) in order to appreciate the object's value [in a monetary term].

The interpretation would then be that the seller (whom might be the producer as well) recognizes the amount of money paid by the purchaser as an indicator of how valuable is the object for the purchaser. Therefore, producers tend to use this indirect-but-tangible indicator to "monitor" the changes in customer's perception about the product's value. This indicator is the exchange value, or how much the customers are willing to give as an exchange for a product or service (in comparison with their perception about the product value). With regard to that money is a conventional standard to measure exchange value (Conti, 2005), and then, in most cases, "price" represents exchanged value.

However, using only price to indicate the value perceived by customers is not appropriate because price, as a measure of value, is relative to other aspects of the market place (e.g. competition), which makes it a poor/convoluted measure of exchange value. Therefore, the definition of exchange value should include two distinct measures, the utility of the product (the absolute measure) and the price of the product (the relative measure). In fact, "[customer perceived] value is ... overall assessment of the utility of a product ..." (Zeithaml, 1988, p. 14).

The point is that the producer's effort should be directed to improve the utility of the product by making the product more "attractive" to the customers. This argumentation is valid because the customers are willing to pay more if they perceive that a product has a high value.

The efforts of making the product "attractive" should also consider a reasonable price level in which this "attractive" product can be sold, because if the price is considered as "too expensive", the customers might not be interested in buying the product.

There are two theories explaining why a customer decides to buy a product: consumer's surplus theory and equity theory (see Padula and Busacca, 2005). The consumer's surplus theory describes that a consumer (or customer) wants to buy the products if the actual price of the product is less than the maximum price that he/she is willing to pay, while the equity theory states that a customer decides to buy a product if the product is sold at a "fair" price level, i.e. that the worth of a product does not significantly differ from its actual price. The surplus theory further describes that the amount of money that a customer is willing to pay may be below or above the actual price, while according to the equity theory, the maximum worth of a product is
equal to the actual price.

The customer's willingness to pay [a certain amount of money] and the worth of a product comprise the definition of the utility concept, where the utility of a product can be higher or lower than a product’s actual price. This implies that when a customer is willing to pay a certain amount of money that exceeds the actual price, he/she may perceive that the product is of value and has a high level of quality.

The way customers evaluate the price of a product (or as Padula and Busacca (2005) refer as the multidimensionality of price) may trigger the necessity to redefine the way we formulate exchange value of a product, in the sense that exchange value should no longer be simply stated as "price". Instead, it should be redefined as the ratio between utility and the actual price of a product (Setijono and Dahlgaard, 2007).

Assuming that customer exchanges are equal to what he/she gets in return, i.e. the equality between exchange value and acquisition value (Setijono and Dahlgaard, 2007), we are able to define and estimate the changes in perceived customer value (PCV) through the changes in exchange value (EV), so that:

\[
\frac{PCV_{i+1}}{PCV_i} = \frac{EV_{i+1}}{EV_i}
\]

(2)

Where:

\( \frac{EV_{i+1}}{EV_i} \): The relative change in exchange value from time i to time (i+1)

Since EV can be defined as a ratio between utility (U) and the actual price (P), the changes in EV can be reformulated as:

\[
\frac{EV_{i+1}}{EV_i} = \frac{U_{i+1}}{U_i} \times \frac{P_i}{P_{i+1}} = \frac{RU}{RP}
\]

(3)

Where:

\( RU \) : The relative change in utility
\( RP \) : The relative change in price

The combination of equations (2) and (3) suggests that the increase of utility (\( RU > 1 \)) will increase customer's perception about the value of a product and a decrease of the price (\( RP < 1 \)) will have the same effect.

Quality management as a means to influence customer value

Quality improvements and product's utility

The way customers determine the utility of a product involves judgment, such as the overall perception about the quality of the product (Mochimoto and Ohfuji, 2005). Therefore, the producer influences the relative change in utility (RU) through the improvement of design quality or forward-looking quality and the quality of
conformance (backward-looking quality).

**Quality cost and product's price**

It is a common practice that price is defined as a sum of *total cost* and *profit margin*, where the size of profit margin depends on the market condition (monopoly, oligopoly, or perfect competition). The Lean Production methodology (Womack and Jones, 1996) suggests that total cost is the sum of *value-added costs* and *non-value added costs* (see e.g. Liker, 2004). This means that a possible way to increase profit or to decrease price is through continuous reduction of non-value added costs (i.e. the costs of activities which occur due to system's imperfection). These costs can be identified and measured using the Prevention-Appraisal-Failure costs (PAF) approach. The suggestions of Liker (2004) and Mochimoto and Ohfuji (2005) imply that a change in quality (Q) and in non-value added costs influence a change in customers' perceptions regarding the value of a product. Thus, equation (3) can be redefined as:

\[
\frac{R_{Q}}{R_{P}} \approx \frac{R_{Q}}{R_{COQ}}
\]

Where:
- \(R_{Q}\): Relative change in quality
- \(R_{COQ}\): Relative change in quality cost (COQ), in which COQ is a sum of prevention (P), appraisal (A), and failure (F) costs

However, the mechanism is quite complex because value-added quality costs (i.e. prevention and appraisal costs) has causal effects on both non-value added quality costs (failure costs) and the indicators of quality performance. Therefore, defining quality costs as the sum of prevention, appraisal, and failure cost: 1) makes the effect of prevention and appraisal on the reduction of failure costs vague, 2) neglects the fact that there are quality aspects which cannot be easily stated in financial terms and ignores the importance of those aspects, and 3) ignores the fact that failure costs only explain quality from one side ("negative" side), while quality is a concept that can be explained from both "positive" and "negative" sides. Consequently, quality costs should be expressed in such a way that it recognises the value of quality improvements and be linked to customer value. This issue can be addressed by adjusting equation (4), which is described in the following sub sections.

**Model of proactive quality costs measurement**

According to Chung (2001, p. 130), "The optimisation of subsystem does not equal to system optimisation". Using line balancing as an example, Chung (2001, p. 132) concludes "Line balancing activities for the process must be performed continuously for system optimisation. If not, improvement may be sub optimal [and only] increasing idle time". These two statements imply that a system may be imperfect and imperfect systems would eventually trigger cost (Campanella, 1990; in Dahlgaard et al 1998; Kolarik, 1995). The costs due to system's imperfection are manifested through failure costs, which include not only the costs due to defects but also opportunity costs (Kondo, 1993) or in other words, failure costs include both visible and invisible costs (Dahlgaard et al, 1998). In order to reduce failure costs, prevention and appraisal activities are necessary.
Chung (2001, p. 127) further states that "... the efforts of improving quality [through prevention and appraisal activities] bring not only reducing the failure costs but also many other benefits which are tangible or intangible". This statement implies that the effects of quality improvements do not merely manifest into a change in failure costs but also other benefit-related quality performance results.

Kondo (1993) describes that increased quality performance (Q) will decrease failure costs (F), and at the same time argues that the efforts to improve quality can be performed creatively, meaning that the same or higher level of quality performance can be achieved with lower prevention and appraisal (PA) costs (figure 1).

![Quality of conformance](image)

**Figure 1. Creative quality improvements**

Based on the thoughts of Kondo (1993) and Chung (2001), we conclude that:
- A discussion about quality improvement should include PA (the effort), an indicator that explains quality-construct from the "positive" side (in this case, it is simply defined as Q), and an indicator that explains quality-construct from the "negative" side, i.e. the failure costs (F).
- The prevention-appraisal activities (PA) have a direct effect on quality performance (Q) and subsequently affect the failure costs (F) because changes in quality performance will influence changes in failure costs.

Using these two points, a general model of the value of quality improvements will be constructed. After the suggested general model, two specific models of the value of quality improvements are suggested.

**General model of the value of quality improvements**

From the producer's perspective, assessing quality improvements is [essentially] a comparison between the benefits (i.e. changes in quality (Q) and failure costs (F)) gained from the improvements and the expenses to perform prevention and appraisal activities (PA). As a part of the job description of quality staffs or workers, it wouldn't be easy to point out whether a performed task is either P or A [because it might be a combination]. This became the motivation not to separate P and A. Treating P and A as a synergy may (depending on industry characteristics and the level of quality
advancement in a company) provide a better explanation regarding the relationship between the efforts and the results of quality improvements.

The ratio between the benefits of improvement and the expenses is defined as the *value of quality improvements* considering that value is a ratio between benefits and costs. Hence, the value of improvement may be expressed as a two-dimensional vector ($v$):

$$v = \left( \frac{R_Q}{R_{PA}} \right) \hat{x} + \left( \frac{R_F}{R_{PA}} \right) \hat{y}$$  \hspace{1cm} (5)

Where:
- $R_{PA}$: The relative change in prevention and appraisal related expenses
- $R_Q$: The relative change in quality performance results
- $R_F$: The relative change in failure costs
- $\hat{x}$, $\hat{y}$: The directions (coordinates) of the value vector

The change in quality ($Q$) will likely influence customers' perceptions regarding the benefits of the product, while the change in failure costs ($F$) will likely influence customers' perception regarding the sacrifices to acquire the product. The changes in the prevention-appraisal costs ($PA$) and failure costs ($F$) are usually measured in terms of money (e.g., $, £), and the change in quality performance ($Q$) is measured in terms of percentage (0-100%). These are the *absolute* measurements of $PA$, $Q$, and $F$, which are expressed in terms of *differences* ($\Delta$) and take *zero* (0) as a reference point. However, it is also possible to measure the changes of $PA$, $Q$, and $F$ in *relative* terms ($R$), where *one* (1) is the reference point. These alternative types of measurement are not contradictory – we just used different measurement scales. In this paper, the change of $PA$, $Q$, and $F$ are measured in relative terms.

The analytical model (5) suggests that changes in prevention and appraisal activities affect both the benefits from the changes in failure costs and quality performance. The former part of the equation ($R_Q/R_{PA}$) indicates the direct effect of improvement efforts, while the latter part of the equation ($R_F/R_{PA}$) indicates the subsequent effect of improvement efforts (meaning that the quality performance must be improved first before the failure cost can be reduced). Although the model does not accommodate the time lag of performance improvements, the value measurements indicate whether the overall relative benefits achieved through improvements are higher than the relative expenses to perform the improvement activities.

Since $PA$, $Q$, and $F$ are measured in a *relative* term (comparison between period $i$ and period $i+1$), the two-dimensional vector is dimensionless (doesn't have unit of measurement, such as kg, m, etc) where the range of measurements are between zero (0) and positive indefinite ($+\infty$). Therefore, equation (5) can be transformed into a *scalar* ($v$), in which:

$$v = \sqrt{\left( \frac{R_Q}{R_{PA}} \right)^2 + \left( \frac{R_F}{R_{PA}} \right)^2}$$  \hspace{1cm} (6)
Transforming the value vector into a scalar makes the value measurement simpler to use rather than if we express the value measurement as a vector because the value scalar is a single measurement (and so is the customer perceived value), while the value vector uses imaginary coordinates (directions) that may not be easy to interpret. The value of improving quality is higher than one as long as the relative change in the expenses related to prevention and appraisal does not exceed the relative change in the benefits gained from the improvements (i.e. improved quality and reduction of failure costs). However, in this measurement, the lower limit of value is $\sqrt{2} = 1.41$, because it is the calculated value when the PA, Q, and F are the same between period i and (i+1) [thus, $R_{PA} = 1$, $R_{Q(1)} = 1$, and $R_{EF} = 1$]. Therefore, a cut-off point of 1.41 should be used to determine whether the efforts of improving quality have resulted in a valuable return or not.

Specific models of the value measure
Model 1: the value of improving forward-looking quality
The benefit that the producer expects from the performed quality improvements is that the customers' perceptions regarding the quality of the product will be increased. Thus, customers' judgment on quality ($Q(1)$) is the indicator of forward-looking quality. The value of improving forward-looking quality ($v_1$) is therefore:

$$v_1 = \sqrt{\left(\frac{R_{Q(1)}}{R_{PA}}\right)^2 + \left(\frac{R_{EF}}{R_{PA}}\right)^2} \quad (7)$$

Where:

$R_{PA}$ : The relative change in prevention and appraisal related expenses
$R_{Q(1)}$ : The relative change in customers' judgment on quality
$R_{EF}$ : The relative change in external failure costs

The change in prevention-appraisal costs (PA) is defined as the ratio between PA at period (i+1) and PA at period i. Then:

$$R_{PA} = \frac{PA_{i+1}}{PA_i} \quad (8)$$

If PA at period (i+1) is lower than the PA at period (i), the $R_{PA}$ is smaller than one.

The change in failure costs is defined as the ratio between the external failure costs (EF) at period i and the external failure costs at period (i+1). Then:

$$R_{EF} = \frac{EF_i}{EF_{i+1}} \quad (9)$$

If the external failure costs (EF) at period (i+1) is lower than the failure costs at period (i), the $R_{EF}$ is higher than one.

We define $R_{Q(1)}$ as the ratio between the overall customer's cognitive judgment on quality (CCJQ) on period (i+1) and (i). Therefore:
It follows that $R_{Q(1)}$ is larger than one if the CCJQ is improved from period (i) to period (i+1). Considering the practicality aspect, Q(1) may be measured e.g. every six months or annually. If we first measure it at month 1 (i.e. period i) then the next measurement is at month 7 (i.e. period (i+1)). The measurement of $v_i$ in (7) requires that the "distance" between period (i) and period (i+1) of $R_{Q1}$ should be equal to the "distance" between period (i) and period (i+1) of $R_{EF}$ and $R_{PA}$.

CCJQ is a measure of customers’ perceptions regarding the quality of a company's product or service. There are two ways of measuring CCJQ: single-attribute (overall) measurement or multi-attribute measurement. In this study, the author uses multi-attribute measurement because: it takes into account the producer's efforts on quality and it provides indications of what to improve. Thus, CCJQ is the sum of multiplication between the product performance score (P) and the weight of importance score (W) of each selected quality attribute (see e.g. Dahlgaard et al, 1998). In order to eliminate the ambiguity of interpretation, which is caused by the use of different measurement scales (e.g. a 1-5 scale, a 1-7 scale, or a 1-10 scale), we can use a normalized score (NP) for P.

\[
CCJQ = \sum_{j=1}^{n} W_j \times NP_j \quad \text{where} \quad 0 \leq W_j \leq 1, \sum_{j=1}^{n} W_j = 1 \tag{11}
\]

The weight (importance) is the ratio between the important score of a certain attribute and the sum of importance scores for all selected attributes. Normalized performance score (NP) is the ratio between the distance of the original performance score (P) from the minimum possible score in the performance score measurement ($P_{min}$) and the range of the measurement scale.

\[
NP_j = \frac{P_j - P_{min}}{P_{max} - P_{min}} \quad \text{where} \quad 0 \leq NP_j \leq 1 \tag{12}
\]

Example:
During period 1: $PA_1 = 20$, $F_1 = 80$; $W_1 = 1/3$; $W_2 = 2/3$; $P_1 = 4$; $P_2 = 5$.
During period 2: $PA_2 = 25$, $F_2 = 55$; $W_1 = 2/5$; $W_2 = 3/5$; $P_1 = 5$; $P_2 = 6$.

Table I shows the calculation of CCJQ for period 1. Using the same way of calculating, the CCJQ for period 2 is 23/30 as shown by table II.

<table>
<thead>
<tr>
<th>Attribute</th>
<th>W</th>
<th>NP</th>
<th>W*NP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1/3</td>
<td>(4-1)/(7-1) = 1/2</td>
<td>1/6</td>
</tr>
<tr>
<td>2</td>
<td>2/3</td>
<td>(5-1)/(7-1) = 2/3</td>
<td>4/9</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>CCJQ</td>
<td></td>
<td>11/18</td>
<td></td>
</tr>
</tbody>
</table>
**Table II. The CCJQ for period 2**

<table>
<thead>
<tr>
<th>Attribute</th>
<th>W</th>
<th>NP</th>
<th>W*NP</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2/5</td>
<td>(5-1)/(7-1) = 4/6</td>
<td>8/30</td>
</tr>
<tr>
<td>2</td>
<td>3/5</td>
<td>(6-1)/(7-1) = 5/6</td>
<td>15/30</td>
</tr>
<tr>
<td>Total</td>
<td>1</td>
<td>CCJQ = 23/30</td>
<td></td>
</tr>
</tbody>
</table>

Therefore, \( R_{Q(1)} = \frac{23/30}{11/18} = 1.25 \), \( R_{PA} = \frac{25}{20} = 1.25 \), \( R_{IF} = \frac{80}{55} = 1.45 \), and

\[
v_1 = \sqrt{\left(\frac{1.25}{1.25}\right)^2 + \left(\frac{1.45}{1.25}\right)^2} = 1.53.
\]

**Interpretation:**

A 25% increase in quality improvement activities (PA) between period 1 and 2 increased customer satisfaction by 25% and decreased external failure costs by rate of 45%, which means that the value of quality improvements is 8.51% above the cut-off point.

**Model 2: the value of improving conformance quality performance**

Quality improvement efforts may bring benefits such as an increase in the percentage of the produced products that conforms to specifications or backward-looking quality \(Q(2))). Therefore, the value of improving backward quality \(v_2\) is defined as:

\[
v_2 = \sqrt{\left(\frac{R_{Q(2)}}{R_{PA}}\right)^2 + \left(\frac{R_{IF}}{R_{PA}}\right)^2}
\]

We may define:

\[
R_{Q(2)} = \frac{Y_{i+1}}{Y_i}
\]

Where:

\(Y_{i+1}\): The yield (the percentage of conforming products) at period \((i+1)\)

\(Y_i\): The yield at period \(i\)

It follows that \(R_{Q(2)}\) is greater than one if the yield at period \((i+1)\) is larger than the yield at period \((i)\). While \(R_{PA}\) follows the definitions as shown by equation (8), and the relative change in internal failure cost \(R_{IF}\) is measured in a similar way as equation (9). Even though there are additional factors, which might influence yield, yield has been used as an indicator of conformance quality.

Considering the practicality aspect, \(Q(2))\ may be measured e.g. every month or quarterly, while \(Q(1)\) may be measured e.g. every six months or annually. This means that the "distance" between period \((i)\) and period \((i+1)\) for \(Q(1)\) and \(Q(2)\) may not be equally long, but the "distance" between period \((i)\) and period \((i+1)\) of \(R_{Q(2)}\) should be equal to the "distance" between period \((i)\) and period \((i+1)\) of \(R_{PA}\) and \(R_{IF}\). In the case
Q(2) is measured quarterly, if we first measure it at month 1 (i.e. period i) then the next measurement is at month 4 (i.e. period (i+1)).

Example:
Let's assume that:
During period 1: \( Y_1 = 0.8; \) \( PA_1 = 30, \) \( F_1 = 70, \) and during period 2: \( Y_2 = 0.9; \) \( PA_2 = 30, \) \( F_2 = 60. \)

Then we get \( R_{Q(2)} = \frac{0.9}{0.8} = 1.12, \) \( R_{PA} = 1, \) \( R_{IF} = \frac{70}{60} = 1.17, \) and

\[
\nu_2 = \sqrt{\left(\frac{1.12}{1}\right)^2 + \left(\frac{1.17}{1}\right)^2} = 1.62.
\]

The result can be interpreted in the following way:
The same amount of efforts to improve quality (but more creatively) increased the yield by 12.5% and decreased the internal failure costs by a rate of 17%. Thus, the value of quality improvements is 14.89% above the cut-off point.

Case study
The case company described in this paper is a Swedish wood-flooring manufacturer, and one of Europe's leading parquet and wood-flooring producers that mainly serves US and European markets. The average sales revenue during 2003-2004 was more than 200 millions Euros per year.

Selecting the model to be applied
Based on the general model of proactive quality cost (equation (6)), there are two specific models to be applied, i.e. equation (7) and (13). However, considering the company’s priority to first improve quality in the production (where quality cost measurements become the indicator), the case study only demonstrates the applicability of the second specific model of the value of quality improvements (i.e. equation (13)). Another consideration to first apply equation (13) is the emphasis on the necessity of being customer value-oriented when measuring quality cost although those measurements contain data that are identified backward in the production. In this paper, we analysed ten (10) sets of data that have been collected in the case company.

Model validation
The data analysis (see figure 2) indicates that quality improvement efforts do have effects on the quality improvement indicators \( R^2 = 94.61\% \), which supports our reasoning to adjust equation (4) into equation (5) and also validates equation (13).

Figure 2 explains the concept of creative quality improvements in the following way:
- Higher results (from \( y \approx 1.34 \) to \( y \approx 1.54 \)) can be achieved with the same amount of efforts (\( x \approx 0.96 \))
- The same results (\( y \approx 1.40 \)) can be achieved with less amount of efforts (from \( x \approx 1.33 \) to \( x \approx 0.82 \))
Figure 2. The effect of quality improvement efforts on quality improvement indicators

The two “extreme” points, one on the right ($\bar{R}_{PA} \approx 1.70$) and one on the left hand side ($\bar{R}_{PA} \approx 0.56$) have been ignored in the above explanation because they may be regarded as outliers until more data have been collected. When more data are collected around the extreme values of $\bar{R}_{PA}$, the function in figure 2 is likely to change and may then be used as a tool for prediction. Until now, the estimated function in figure 2 was only used to show potential effects of creative quality improvement efforts.

**The operating definition of $Q(2)$**

The yield (stated as a fraction of total output) of thick wood-flooring products (15 mm) are defined as the quality indicator ($Q(2)$), where these data are collected at the final inspection (after profiling process) before the products are packed and delivered to the distribution centre.

**Quality cost identification and measurements**

With reference to equation (4) that has been adjusted into equations (5) and (6), the Prevention-Appraisal-Failure (PAF) model according to British Standard (BS) 6143 was selected to identify the quality cost in the case company because it provides a standardization regarding quality cost. Although the PAF model (and BS 6143) has been put under scrutiny and constructively criticized for a number of reasons (Dahlgaard et al, 1992; Dale and Plunkett, 1999), it does make users aware that failures cause reduced profits and change (i.e. reduction of failures) will improve overall performance and quality (Keogh et al, 1998). Also manufacturing industries mostly implement the PAF model (Keogh et al, 2003) since it is easy to understand and is universally accepted (Dale and Plunkett, 1999), and the method of categorizing quality cost is the most common method in literature (Chiadamrong, 2003). Using a standardized model is beneficial because identifying quality costs requires a “careful” definition of what quality-related costs are because it is not easy to disown a cost.
element after being claimed as quality-related, i.e. the danger of potential backfire of amplifying quality cost (Dale and Plunkett, 1999).

The quality cost identification project was intended as the foundation or the starting point for continuous quality improvement by showing the activities or events that drive quality cost and state them in terms of financial figures. Simplicity and the use of existing data are among the keywords of how quality cost was identified and visualized in the company. Simplicity in this case means that quality cost identification was mostly focused on the cost elements that were "easy to capture" as well as the use of simple mathematical equations to express them. Mathematical equations were used to estimate the costs that are not recorded in the company's accounting/financial system.

A systematic collection of quality costs was suggested to consist of the following serial process: define, streamline, identify, and allocate. Define means "translate" the definition of quality cost elements into the specific industrial context, in this case a wood-flooring manufacturer. Streamlining means to consider the quality cost elements that are applicable to a significant extent in the company. The next step is to identify the cost drivers of the quality cost elements. These three steps were performed as a qualitative study through interviews, brainstorming, and observations. The use of qualitative studies in quality cost identification is common, especially interviews (see e.g. Suresh et al (2000), Keogh et al (2003)).

The last step, allocate, is concerned with the process of allocating costs using bases such as: number of inspections, percentage of total working time (or duration) to perform a certain activity, number of complaints, number of defects, volume of scraps. This process is the quantitative study of quality cost identification, where mathematical algorithms were developed for the purpose of allocation. Figure 3 describes the systematic way of collecting, measuring, and reporting quality costs.

![Figure 3. Systematic collection, measurement, and reporting quality costs](image)

Quality cost reporting is done regularly every month, every quarter, and every year in order to assess the progress of quality improvements.

The system to identify and document quality cost consists of four parts: 1) a file that contains the definition of quality cost elements in the industry/company context, 2) a file that contains mathematical algorithms to describe the way of calculating the costs, 3) a spreadsheet-based cost calculation, and 4) a file used for quality cost
reporting. The quality cost results reported first time by using this system are shown in table III.

Table III. Quality cost results during 2004

<table>
<thead>
<tr>
<th>Category</th>
<th>Portion</th>
<th>Percent of sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prevention</td>
<td>2.5%</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Appraisal</td>
<td>15.5%</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Internal failure</td>
<td>53%</td>
<td>1-2 %</td>
</tr>
<tr>
<td>External failure</td>
<td>29%</td>
<td>1-2 %</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>3-4 %</td>
</tr>
</tbody>
</table>

The internal failure cost is the largest portion of the quality cost measurements and prevention cost is the smallest cost category. The combination of internal and external failure cost is higher than prevention and appraisal. These results are consistent with the characteristics of quality cost as described in the theory section. The figures in table III indicate that the quality activities in the company are managed in a reactive way instead of a preventive way.

The value of quality improvements
The relative change in quality ($R_{Q(2)}$) is calculated according to equation (14), and is shown in table IV.

Table IV. Relative changes in quality

<table>
<thead>
<tr>
<th></th>
<th>$R_{Q(2)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-Feb</td>
<td>0.9997</td>
</tr>
<tr>
<td>Feb-Mar</td>
<td>0.9996</td>
</tr>
<tr>
<td>Mar-Apr</td>
<td>0.9977</td>
</tr>
<tr>
<td>Apr-May</td>
<td>0.9973</td>
</tr>
<tr>
<td>May-Jun</td>
<td>1.0064</td>
</tr>
<tr>
<td>Jun-Jul</td>
<td>0.9958</td>
</tr>
<tr>
<td>Jul-Aug</td>
<td>0.9988</td>
</tr>
<tr>
<td>Aug-Sept</td>
<td>1.0092</td>
</tr>
<tr>
<td>Sept-Oct</td>
<td>0.9998</td>
</tr>
<tr>
<td>Oct-Nov</td>
<td>1.0022</td>
</tr>
</tbody>
</table>

The relative change in prevention-appraisal costs (PA) and internal failure costs (IF) is shown in table V.
Table V. Relative changes in PA and IF

<table>
<thead>
<tr>
<th></th>
<th>$R_{PA}$</th>
<th>$R_{IF}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-Feb</td>
<td>0.9556</td>
<td>0.8993</td>
</tr>
<tr>
<td>Feb-Mar</td>
<td>1.3294</td>
<td>0.9860</td>
</tr>
<tr>
<td>Mar-Apr</td>
<td>0.8194</td>
<td>0.9555</td>
</tr>
<tr>
<td>Apr-May</td>
<td>0.9439</td>
<td>1.0733</td>
</tr>
<tr>
<td>May-June</td>
<td>0.9563</td>
<td>1.1730</td>
</tr>
<tr>
<td>Jun-Jul</td>
<td>0.5640</td>
<td>2.1274</td>
</tr>
<tr>
<td>Jul-Aug</td>
<td>1.6995</td>
<td>0.5172</td>
</tr>
<tr>
<td>Aug-Sept</td>
<td>1.1190</td>
<td>0.8759</td>
</tr>
<tr>
<td>Sept-Oct</td>
<td>1.0699</td>
<td>0.8539</td>
</tr>
<tr>
<td>Oct-Nov</td>
<td>0.9796</td>
<td>1.0471</td>
</tr>
</tbody>
</table>

The value of improving the conformance quality was estimated using equation (13). However, as discussed above, the calculated value measurements are sensitive to "extreme" changes of its variables and because of that, it is not always easy to "extract" a meaningful interpretation from a fluctuating figure. This problem may be overcome by smoothing the results using Exponentially Weighted Moving Average (EWMA) method (see e.g. Wadsworth, 2000). By using this method, fluctuations are reduced and shifts can be detected, which facilitate interpretation of the results.

Table VI shows the value of improving backward quality ($v_2$) and the EWMA of $v_2$, where the initial value of EWMA ($v_2$) is set at 90% of $v_2$ during Jan-Feb and the smoothing factor is 0.1, which is one of the most commonly used smoothing factors (Wadsworth, 2000). The result is plotted in figure 4.

Table VI. The value of improving the conformance quality

<table>
<thead>
<tr>
<th></th>
<th>$v_2$</th>
<th>EWMA ($v_2$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan-Feb</td>
<td>1.4072</td>
<td>1.2665</td>
</tr>
<tr>
<td>Feb-Mar</td>
<td>1.0562</td>
<td>1.2455</td>
</tr>
<tr>
<td>Mar-Apr</td>
<td>1.6859</td>
<td>1.2895</td>
</tr>
<tr>
<td>Apr-May</td>
<td>1.5521</td>
<td>1.3158</td>
</tr>
<tr>
<td>May-June</td>
<td>1.6161</td>
<td>1.3458</td>
</tr>
<tr>
<td>Jun-Jul</td>
<td>4.3022</td>
<td>1.6414</td>
</tr>
<tr>
<td>Jul-Aug</td>
<td>0.6618</td>
<td>1.5435</td>
</tr>
<tr>
<td>Aug-Sept</td>
<td>1.1942</td>
<td>1.5086</td>
</tr>
<tr>
<td>Sept-Oct</td>
<td>1.2230</td>
<td>1.4800</td>
</tr>
<tr>
<td>Oct-Nov</td>
<td>1.4866</td>
<td>1.4807</td>
</tr>
</tbody>
</table>
If we take $v = 1.41$ as a cut-off point, figure 4 indicates that between January and June, the value of improving the conformance quality was below the cut-off point (although it is increasing), while between July to November, the value of improving conformance quality was above the cut-off point. Thus, the quality improvement efforts during the last six months fulfil the expectations, meaning that benefits were higher than the expenses.

**Discussion**

In this article, relative measurements of value were used which enabled us to combine different types of measurement scales and the transformation of the value vector into a scalar simplifying the value measurement.

The way customers perceive the value of a product is a function of the value of quality improvements, where it is assumed that the function is positive and increasing, meaning that when the value of quality improvements goes up, the relative change in perceived customer value also goes up. This implies that valuable quality improvements are the means to influence the perceived customer value of a product, and the dynamics of customer value is the result of continuous improvement efforts to increase the quality of a product and/or decreasing the costs due to non-conformance.

The changes in prevention-appraisal costs, failure costs, and yield are the determining variables whether the improvements have given more than fair return ($v > 1.41$), relatively fair return ($v \approx 1.41$), or less than fair return ($v < 1.41$). In other words, the value of quality improvements indicates the return on quality improvement (ROQI), which measures the return on the “investments” (in terms of employees’ efforts and knowledge as well as other resources) to reach a higher level of quality performance. It might be important to note that when $v < 1.41$, it should not be interpreted as an indication of failure in quality improvement. Instead, it may indicate that the efforts of
improving quality could have been performed smarter in order to have a stronger effect on the value to both producer and customers.

Conclusions
The weakness of the existing concept of quality costs is obvious when we reflect on the fundamental purpose of quality management, i.e. creating customer satisfaction and value. Hence, measuring quality performance should not just involve costs viewed from producer's perspective, but it should also be about measuring quality performance in terms of value seen from customers' perspective.

Understanding and improving quality cost in a value-context is to think proactively, because quality cost measurements: 1) can be used to assess whether the improvement activities were valuable (gave more benefits compared to the expenses), and 2) can lead to an understanding that the efforts of improving product and process quality, also influence the way customers perceive the value of the product.

This paper has described a new method for measuring quality costs (define, streamline, identify, and allocate) and transforming the measurements into value of quality improvements (ROQI). The value measure (ROQI) indicates that quality improvement efforts are valuable (give more than fair return) if the gained overall benefits (the increase of a quality indicator, e.g. yield, and the decrease of failure costs) are higher than the costs to perform improvement activities, or if the same or higher benefits can be gained at the same or lower expenses.

The method has been theoretically developed and tested in a Swedish wood flooring manufacturer. More empirical tests are needed to give further insights regarding practical implementation problems in other industries.

References


The Added-Value Metric – A Complementary Performance Measure for Six Sigma and Lean Production

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Abstract

The Six Sigma and Lean Production methodologies suggest that creating value for customers is the objective of a production process or an organisation. In the production context, “added value” dominates the discussion about the creation of value to customers. However, “added value” is often only defined conceptually or discussed at a strategic level, and the link between added value and customer value has not yet been well conceptualised. Therefore, the purpose of the paper is to develop a methodology to measure added value in order to complement the existing performance measures in Six Sigma and Lean Production by conceptualising the link between customer value and added value. The conceptual link “confirms” that quality, time, and costs are the elements of added value, which are transformed into a metric to express customer value. The implementation of the metric recommends the adoption of Lean (Six) Sigma and Lean Accounting (Activity Based Costing), which thus implies that “leanness” is an important “feature” of added value.

Key Words: Added Value, Performance Measure, Customer Value, Six Sigma, Lean Production

1. Introduction

According to Conti (2005), an organization is a system that generates [customer] value. This statement implies that a firm is a value-adding operation (Gröñoos, 1996) or system (Fawcett and Fawcett, 1995), where the value added by a firm is the value created by all the players in the vertical chain minus the value created by all the players except the one in question (Branderburger and Stuart, 1996; in de Chernatony et al., 2000). Moreover, the

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Six Sigma and Lean Production methodologies suggest that the objective of a production process is to create, deliver, and improve customer value (Womack and Jones, 1996; Breyfogle, 2001; Liker, 2004). Thus, added value becomes a company’s attempt to provide value for its customers. Hence, in the production context, customer value is “acknowledged” as added value under a circumstance that in different contexts, customer value may “appear” in different “modes” (Setijono, 2005).

The hypothetical relationship or association between added value and customer value has been described by, e.g. de Chernatony et al. (2000) and Grönroos (1997), besides that the relationship seems to be well grounded within the principles of Lean Production. According to de Chernatony et al. (2000), added value enables organizations to deliver superior customer value as well as enables customers to recognize superior value and be more confident in their choice. The term “customer value” stated by de Chernatony (2000) refers to the value recognised by customers prior to the purchase or acquisition of a product, i.e. perceived customer value. The hypothetical relationship between added value and customer value suggested by de Chernatony (2000) seems to be consistent with the way Grönroos (1997) defines the relation between [perceived] customer value and added value, that *Perceived Customer Value = Core Value ± Added Value*. This relation implies that added value may have a positive or negative impact on perceived customer value.

Gale (1994) suggests that perceived customer value is the ratio between market perceived quality and market perceived price. Meanwhile, Harry and Crawford (2005) defines added value as a function of utility, access, and costs. Although Grönroos (1997) and Gale (1994) discuss the same concept, their descriptions and/or formulations indicate a divergence. Therefore, comparing these two definitions might be confusing. A possible explanation is that Gale (1994) explains perceived customer value from the purchaser’s (customer’s) point of view, while Grönroos (1997) explains a similar concept from the view of a service provider (producer).

The five principles of Lean Production [i.e. defining customer value, identifying the value stream, making the value creation steps flow, let the customers pull the value from the value stream, and pursue perfection in creating value] (see e.g. Womack and Jones, 1996; Liker, 2004; Dahlgaard and Dahlgaard Park, 2006) contain the philosophy that the way a company creates value to its customers will influence the customers’ perception about value. The main “message” behind the five principles of Lean Production is that the producer first interprets (define) customer value into several specific criteria. These criteria determine the value stream, where the “value” flows along the defined stream, so that the customers can pull the value from the producer at the time they wish. The way of expressing value also needs to be continuously improved towards perfection.

Hence, we notice that: 1) the hypothetical relationship or association between added value and customer value is somewhat fuzzy, in the sense that there is no adequate conceptualisa-
tion provided, although the relationship between added value and customer value exists theoretically and is acknowledged by researchers, and 2) this fuzziness might be the reason behind the “absence” of performance measures which adequately reflect the notion of customer value. This is probably why the performance measures in Six Sigma and Lean Production inadequately indicate the success (eventually failure) of a company in providing and/or improving customer value.

Therefore, the purpose of this paper is to explain the conceptual link between added value and customer value in order to understand in what way added value enhances customer value, so that the suggested methodology to measure added value may be used to indicate the customer value creation.

The paper will be organized in the following way: first, the authors will provide a theoretical review about customer value and performance measures in Six Sigma and Lean Production. Then, a conceptual link between added value and customer value will be described. Next, the authors suggest a methodology to use the added value as a metric to measure performance. The paper finalizes with conclusions.

2. Literature Review

2.1 Performance Measures in Six Sigma and Lean Production

According to Breyfogle et al. (2001), the metrics used to measure performance must be related to customer value. However the existing Six Sigma metric, i.e. number of defect per million opportunities (dpmo) does not seem to reflect the customer-value orientation because: 1) quality, as an important component of customer value is not merely about defects and it is not adequate to measure quality based on just defects, 2) customer value as a metric, is a function of carefully selected cost elements, and the dpmo in itself “fails” to show or express this relation in its metric.

The weaknesses of the dpmo metrics become more obvious if we consider the statement of George (2002) that the dpmo is not always applicable at a corporate level or in service-oriented companies due to the fact that it is not always easy to define and count defects. George (2002) further states that many Six Sigma practitioners have not yet addressed the issue of the importance of non-manufacturing defects related to dpmo or their value.

A similar phenomenon can also be found in Lean Production, where the performance measure does not well reflect the intended goal to be achieved. The main goal of Lean Production is to provide customer value (Womack and Jones, 1996; Hines et al., 2004), but the application of lean thinking at the operational level, i.e. in terms of shop-floor tools, does not apply this principle (Hines et al., 2004). The “success” in providing customer value is measured through cycle time, under the assumption that the reduction or elimination of
waste will create a smoother flow and a shorter cycle time. Time is certainly an important element of customer value, but measuring customer value merely in terms of cycle time is considered to be inadequate.

2.2 Customer Value in the Context of Production

There is a “universal agreement” that value is a means to gain competitive advantage (Grönroos, 1997; de Chernatony, 2000; Huber et al., 2001; Khalifa, 2004) besides its extensive application in various disciplines (Wikstrom and Normann, 1994; in Huber et al, 2001). Although it is “agreed” that customer value is generally defined as a ratio between benefits and sacrifices (see e.g. Gale, 1994; Raval and Grönroos, 1996; Dumond, 2002; Khalifa, 2004), value is a complex and difficult-to-define term (de Chernatony et al, 2000; Khalifa, 2004) because “… the value concept is multifaceted and complicated by numerous interpretations, biases, and emphases” (Huber et al., 2001; p. 42).

Setijono (2005) suggests that, in the context of production, customer value manifests into added value. Added value becomes the cues to recognize superior customer value that may lead to confidence in choice (de Chernatony et al, 2000). Hence, it may imply that added value is a “trade mark,” which “certifies” that the product is valuable for customers in the sense that customers “get” more than what they “give” (i.e. the benefits is higher than the sacrifices). Harry and Crawford (2005) provide a conceptual formulation of added value (AV), that:

$$AV = \frac{U \ast A}{C}$$  \hspace{1cm} (1)

Where U is the utility, A represents access, and the cost is defined as C. Equation (1) implies that the added value to customers is reduced if the product is not easily accessed when needed (A < 100%) and/or if the product is too costly, although the product has “perfect” utility (U = 100%).

3. Linking Added Value and Perceived Customer Value

3.1 First-order and Second-order Models of Perceived Customer Value

Defining perceived customer value, as a ratio between “overall benefits” (such as market perceived quality) and “overall sacrifices” (such as market perceived price) represents a second-order model of perceived customer value. Thus the relation between “benefits” and “sacrifices” with the construct of perceived customer value is formative, which means that the “benefits” and “sacrifices” are the components of perceived customer value or have a
causal effect on it (Lin et al., 2005). It is likely that we could select several variables to describe what “benefits” and “sacrifices” consist of when we “break down” or “disaggregate” the “benefits” and “sacrifices.” The result leads to a first-order model of perceived customer value, where the “benefits” consist of “get 1,” “get 2,” … “get n” (variables that are related/associated to the benefits gained by the customers) and the “sacrifices” consist of “give 1,” “give 2,” … “give n” (variables that are related/associated to the sacrifices that the customers need to make when obtaining the product). Unlike the second-order model, the first-order model is reflective, which means that those selected variables are the manifestation or the effect of perceived customer value (Lin et al., 2005).

Figure 1 describes the first-order and the second order models of customer perceived value. The figure is adapted from Lin et al. (2005) with modifications

![Figure 1. The conceptualisation of perceived customer value](image)

Lapiere (2000) uses first-order dimensions (where each dimension consists of several variables) such as product quality, responsiveness, reliability, price, time/effort/energy, etc and classifies these dimensions into the following categories: product-related, service-related, and relationship related. Lin et al. (2005) use “constructs” (where each construct also consist of several variables) such as monetary sacrifice, fulfilment/reliability, customer service, (the efficiency of) website design, etc. With this background, we classified the first-order dimensions as described in Lapiere (2000) and the constructs as described by Lin et al. (2005) into the following categories: quality (of product, services, and relationship), time, and price. The “new” way of categorizing the first-order dimensions (constructs) becomes the key to under-
stand the link between added value and customer value.

3.2 Convergence Meanings/Interpretations of Added Value

Viewing the first-order variables of perceived customer value from a different angle leads to an understanding that quality, costs, and price are important manifestations (or indicators) of customer [perceived] value. This finding is consistent with the statement of Womack and Jones (1996, p. 141) regarding customer value that it should be "...defined in terms of a specific product with specific capabilities offered at a specific time and price." Kippenberger (1997) discussed that a product with specific capabilities offered at a specific time and price is a meaningful expression of customer value. Thus, the product’s capabilities, time, and price are producer’s view regarding what customer value comprises.

According to Harry and Crawford (2005), added value can be defined as a function of utility, access and costs. Harry and Crawford describe utility as "the form, fit, and function of the product," and access as "factors such as the volume produced, the timing of availability to the market, and the location of distribution" (ibid, p. 130). It is then clear that utility refers to quality, while access is related to time.

Considering that 1) product capabilities are the basis for customers to judge product quality, and 2) price is a sum of costs and margin, then the definitions of value suggested by Harry and Crawford (2005) and Womack and Jones (1996) reached a consistency (convergence) in meaning or interpretation. Thus we conclude that added value is the manifestation of customer value in a production context, which comprises quality, time, and costs.

Hence, it is suggested that added value (AV) is defined as:

$$AV = \frac{Q \times T}{C}$$  \hspace{1cm} (2)

From (2), it follows that the condition for improved added value is that at least one of the following requirements is fulfilled: improved quality (Q), improved time (T), and reduced cost (C). This formula is useful as the basis to develop a metric to measure added value in relation to customers.

3.3 Conceptualization of the Link between Added Value and Customer Value

The description from the previous section has “revealed” the “invisible” link between added value and customer value, and it has been described that the basic “ingredients” of added value are quality, time, and costs. However, the complexity of conceptualising the link between added value and perceived customer value may stem from the fact that: 1) it involves two entities and two different contexts, where supplier (producer) and customers may have different interpretations of quality, time, and costs, and 2) it may be risky if the inter-
pretation and the expression of value doesn’t “match”. Incorrect interpretation and expression may lead to a failure in recognizing superior customer value, and thus the “absence” of a purchase transaction. Therefore, conceptualising the link between added value and customer value is a “delicate” matter and requires careful reflections. The following description conceptualises the link between added value and customer value.

The customers prefer to buy a product or service, which is capable to fulfil their needs and/or goals. Thus, customers judge product or service quality based on the capability to fulfil their goals or needs. However, the producer (supplier) interprets quality as: 1) the attractiveness of the product to the customers and 2) the product should be free from defects. Through these interpretations, the producer may expect that the product will likely satisfy customers’ needs and intended goals.

Customers’ view regarding time is that the product or service should be available when needed or just-in-time (Womack and Jones, 2005). However, the producer interprets just in time (JIT) as a shorter and shorter cycle time. Even though shorter cycle time is a “misconception” of the actual JIT meaning, it enables the producer to ensure that product or service is available when it is needed.

![Diagram](image)

**Figure 2.** Added value as the enabler of customer value

The customers prefer that the price should be fair (Padula and Bussaca, 2005). When the price is fair, it might also be perceived as cheap. The perception of fairness or cheapness is a result of comparison between the customer willingness to pay and the actual price offered by the producer, and thus it may not always be associated with a lower price. However, the
producer interprets fair or cheap as a continuous reduction of product cost. Even though a continuous reduction of product cost may not be a “correct” interpretation of fair or cheap, it enables the producer to ensure that the price offered would not exceed the price level that the customers are willing to pay.

Figure 2 provides a [visual] conceptualisation of the link between added value and perceived customer value, as well as explains how added value becomes the enabler of customer value. The figure may enable companies to develop a methodology to measure added value.

4. Measuring Added Value

According to Anderson and Narus (2004), customer value consists of the following elements: product leadership, customer intimacy, and operational excellence. De Chernatony et al. (2000) stated that “focus on process” is an important character of added value, and it is the property that makes added value an enabler of customer value. This implies that added value should be measured in the core processes (or value streams).

Six Sigma and Lean Production are process-oriented methodologies that may help companies to achieve product leadership, customer intimacy, and operational excellence. Six Sigma is output-oriented, which explains why $dpmo$ is the most important measure in Six Sigma. Meanwhile, Lean Production is activity-oriented, which explains why faster flow (shorter cycle time) is the most important measure in Lean production. Therefore, the synergy (fusion) between Lean Production and Six Sigma may increase and optimise added value (Arnheiter and Maleyeff, 2005).

These two methodologies have also different views regarding cost and costing. In Six Sigma, the costs are likely determined in a traditional way (product-based). Lean Production, on the other hand, views that costs occur due to a consumption of resources in certain process activities, and thus, it is activity-based (Bhasin and Burcher, 2006). This might explain why Six Sigma emphasizes defect reduction in order to reduce costs, while Lean Production emphasizes smoothing the process flow by reducing or eliminating non-value added activities in order to reduce costs.

Therefore, the implementation of Lean Sigma needs to consider a costing method that reflects customer orientation. Activity Based Costing (ABC) may fulfil this requirement because it is based on the assumption that costs are driven by resource consumption in the processes or activities to give what customers want and value (Lebas, 1995). The application of ABC may support the identification of activities that add and do not add value to customers, which allows a company to identify improvement opportunities to reduce or avoid “waste”. This might be the reason that ABC is also known as Lean Accounting (Schonberger, 2005; Bhasin and Burcher, 2006).
Consequently, the application of ABC is a way to identify non-value added costs (or the quality costs) that takes into account the view of Lean Production regarding costs and costing. Tsai (1998) describes that cost of quality can be identified and measured by using Activity Based Costing (ABC), where the cost of quality is defined as the sum of value-added quality costs and non-value added quality costs. Here, value added quality costs include the costs for preventing failures, while non value-added quality costs are costs of appraisal and costs due to failures (internal and external failures).

The Lean Production (Toyota Production System) methodology defines added value as the actual transformation process or the core process that the customer is paying for, and everything that is not a part of the core process actually does not add value to the customers and will therefore be regarded as “waste” (Liker, 2004). The waste or non-value added could further be classified into necessary waste (e.g. inspections, control systems to check that procedures are being followed, documentation) and pure waste (e.g. failures, reworks). An example from a Danish company (see Dahlgaard and Dahlgaard Park, 2006) showed that a large portion of salary costs for running a service process were spent on waste of different kind. Between 40~50% of the paid working time was used to identify and correct failures, and the same percentage was used to produce non-value added output.

The two concepts of added value overlap each other and they actually fit perfectly if we see them from the right angle. These two concepts are actually explaining similar things from different perspectives.

The non-value added output or activities (i.e. the wastes) add extra costs ($\Delta C'$) to the “ideal product cost,” defined as the costs when “quality is perfect” or there is no waste. This means that $\Delta C'$ is the difference between actual product costs ($C$) and the product costs when quality is perfect ($C^*$). Campanella (1990; in Dahlgaard et al., 1998) defines this as the cost of quality ($COQ$). Hence we may express that:

$$COQ = \Delta C = C - C^*$$  \hspace{1cm} (3)

It may then be obvious that the costs of quality are actually non-value added costs. It should also be recognised that a certain cost category in quality costs (i.e. prevention costs) is valuable for the producer to generate (create) what is valuable for the customers.

To sum up, the costs of quality should represent (reflect) both necessary and pure waste, where the costs are measured according to a process-based or activity-based model. The seven types/criteria of waste (Liker, 2004) provide guidelines to determine whether an activity adds value or not.

4.1 Customer Value as a Metric for Improvement Measurement

There are two complementary strategies to improve customer value. The first strategy is to
focus on product development, where “customer voices” and new understandings of customers’ latent needs become the input. The second strategy is by focusing on process improvements, where elimination of waste along the value stream is the key. In the second strategy, waste is defined as anything that does not add value to customers, such as failures and other non-value adding activities or output. The improvement efforts to increase the added value should then be focused in either improving the benefits (1st strategy) or reducing unnecessary costs (2nd strategy).

In order to be able to use value added as an operational metric to measure the progress of improvement, we need to ensure that the components of added value have the same unit of measurements. Therefore, the added value to customer (AV) as a metric to measure performance is defined as:

$$AV = \frac{Q_r \ast T_r}{C_r}$$  \hspace{1cm} (4)

Thus, added value is a function of the relative performance of quality ($Q_r$), the relative performance of time ($T_r$), and the relative performance of cost ($C_r$).

Relative performance of quality ($Q_r$) can be defined as the ratio between the yield ($Y$) at period ($i+1$) and yield at period ($i$). Yield is defined as the percentage of output that conforms to the specifications, i.e. the ratio between the amount of acceptable products and the total amount produced. Then:

$$Q_r = \frac{Y_{i+1}}{Y_i}$$  \hspace{1cm} (5)

The waste does not only influence costs, but also cause a longer cycle time than necessary, due to the time consumed by non-value added activities. Therefore, the cycle time ($T_C$) can be generally expressed as a sum between value-added time ($T_{VA}$) and non-value added time ($T_{VA}$). A more effective and efficient operation is expected to reduce the non-value added time, and therefore reduce the cycle time. Hence:

$$T_C = T_{VA} + T_{VA}$$  \hspace{1cm} (6)

From (6), we define the fraction of value added time ($\nu$), which is defined as a ratio between value-added time ($T_{VA}$) and the cycle time ($T_C$). Hence:

$$\nu = \frac{T_{VA}}{T_C}$$  \hspace{1cm} (7)

Relative performance of time ($T_r$) is defined as a ratio between the fraction of value-added time ($\nu$) at period ($i+1$) and the fraction of value added time at period ($i$). Then:
\[ T_r = \frac{\nu_{i+1}}{\nu_i} \]  

Therefore:
\[ T_r = \frac{T_{VA(i+1)}}{T_{VA(i)}} \cdot \frac{T_{C(i+1)}}{T_{C(i)}} \]  

The relative performance of cost \( (C_r) \) is defined as the ratio between non-value added costs \( (C_{VA}) \) at period \((i+1)\) and non-value added costs at period \((i)\). Then:
\[ C_r = \frac{C_{VA(i+1)}}{C_{VA(i)}} = \frac{COQ_{i+1}}{COQ_i} \]  

The analytical model of added value is consistent with the fundamental definition of customer value (i.e. a ratio between “benefits” and “sacrifice”). In fact, added value becomes the producer’s way to express customer value, where reduced number of defects and faster cycle time increase the customers’ perception regarding the benefits and reduction of non-value added costs is producer’s attempt to reduce customers’ sacrifice in getting the benefits. The producer’s way of expressing and improving customer value towards sustainable customer value through the entire product’s life cycle requires the adaption of Lean Sigma and Lean Accounting, which then implies that “leanness” is a crucial “feature” of added value.

Example:
Let’s consider the data as shown by Table 1 in order to calculate the added value.

<table>
<thead>
<tr>
<th>Table 1. Illustrative data</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td>Yield (%)</td>
</tr>
<tr>
<td>Value added time (min)</td>
</tr>
<tr>
<td>Cycle time (min)</td>
</tr>
<tr>
<td>Cost of quality (SEK)</td>
</tr>
</tbody>
</table>

Thus, added value is:
\[ AV = \frac{0.90 \times \left( \frac{103}{105} \times \frac{135}{130} \right)}{18,500/20,000} = 1.166 \]

Based on the result, we may interpret that during period \((i+1)\) the company has improved its performance and added 16.6% more value to the customers.
5. Conclusions

Customer value is the “ultimate” goal of Six Sigma, Lean Production, and Lean Sigma methodologies. However, the existing ways of measuring performance hardly indicate (represent) the concept of customer value itself, which might be caused by a “fuzzy” conceptualisation of the link between the value to customers from customers’ perspective (i.e. customer value) and the value to customers from producer’s perspective (i.e. added value). Therefore, in order to overcome this inconsistency, it is necessary to clarify the conceptual link between customer value and added value, which allows us to express added value as a performance measure. The utilization of customer value as a metric is expected to provide a “better” performance measure for both Six Sigma and Lean Production methodologies.

References


Selecting Improvement Projects that Add Value to Customers

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Abstract

This paper presents a methodology to nominate and select improvement projects that are perceived as adding value to customers (both internal and external). The structure of the methodology can be explained in three “stages.” First, the methodology suggests a new way of categorizing improvement opportunities, i.e. reactive-proactive, to “upgrade” the little Q – big Q categorisation. Then, it develops a roadmap that links performance indicators and improvement projects for both reactive and proactive improvements. Finally, it suggests an algorithm to select the improvement project, where the assessment of to what extent the nominated improvement projects add value to customers relies on the comparison between Overall Perceived Benefits (OPB) and Overall Perceived Efforts (OPE). The improvement project perceived as having the largest impact on adding value to customers receives the highest priority.

Key Words: Project Selection, Quality Improvements, Perceived Added Value, Customer Value

1. Introduction

The “classical” Juran’s version views and classifies quality improvements into “little Q” and “big Q.” Viewing quality improvement in this way seems to be out of date when we consider the latest versions of quality improvement methodologies, i.e. Six Sigma quality and Lean Production, where customer value is the “ultimate” goal and the main reason to improve performance. Without reference to customer value, improvement programs will only exhaust management without generating (increasing) customer value, differentiate the com-
pany’s offering, or enhance profitability (Maklan and Knox, 1997), unless the potential contribution of programs on customer value becomes the basis of selecting improvement programs.

According to De Feo and Barnard (2004), quality improvements comprise a number of journeys of both diagnostic (finding the root causes of a problem) and remedial (changes in the process in order to remedy the root causes as well as establishing new controls in order to hold the gains), which can be described by two alternative versions of quality improvement, i.e. the classic “Juran” version and Six Sigma. In order to improve quality, Juran’s model suggests that we: identify a project, establish the project, diagnose the cause, remedy the cause, hold the gains, and replicate results and nominate new projects. While the Six Sigma methodology suggests that we follow the path of: define, measure, analyze, improve, and control (DMAIC) in order to improve quality. Although these two models seem different in “anatomy,” they have a similar “content.”

The efforts of improving quality acknowledge, to a large extent, the importance of projects because “all improvement takes place project by project and in no other way” (Juran, 1989; p. 35), and project selection (i.e. a series of steps of nomination, selection, mission statement, and publication) is an essential part of a structured quality improvement approach (Juran, 1989). Therefore, it is clear that project selection is one of the critical aspects in quality improvement.

A project is defined as “a problem scheduled for a solution—a specific mission to be carried out” (Juran, 1989), or in the context of Six Sigma, a project is defined as “a problem scheduled for a solution that has a set of metrics that can be used to set project goals and monitor progress” (Snee, 2001; p. 66). We may then redefine a project as a series of activities of goal setting, problem solving (or carrying out the mission), and progress monitoring. This definition implies the importance of project selection, in the sense that the selected project should have the biggest enforcement on the achievement of the goal or the mission. Unfortunately, it is a common phenomenon that the link between performance indicators (such as quality cost measurements) and improvement projects is often unavailable (Juran, 1989).

Project selection is arguably the most difficult aspect of Six Sigma (Snee, 2005). If it is not conducted properly, the Six Sigma initiative can be at risk because organisations may loose belief to the initiative (Snee, 2001). Selecting the wrong projects (i.e. picking just easy projects and sidestepping the “right” projects because they are perceived to be difficult, and addressing the wrong problem) is “deadly” (Zimmerman and Weiss, 2005). Pyzdek (2003; p. 190) states: “far too many black belts fail because they are not discriminating enough in their selection of projects. If project selection is systematically sloppy, the entire six sigma effort can fail”. Selection of good projects is a major factor in the early recognition of Six Sigma within any organization (Antony et al., 2004), and effective project selection is a key
factor in determining the effectiveness of Lean Sigma effort (George, 2004). Thus, there should be a better manner to categorise the selection and nomination of improvement projects (in general) and Six Sigma projects (in particular).

To sum up, nominating and selecting improvement projects could be difficult and problematic because: 1) the roadmap(s) that connect the performance indicator and project selection is often unavailable, and 2) the “big Q and little Q” categorisation may not be adequate to discriminate and select the “right” improvement projects from the “wrong,” when it regards the accomplishment of the goal to provide value to customers. Therefore, the purpose of this paper is to present a new way to distinguish improvement projects, and to develop a roadmap that links performance indicators and project selection.

The paper will be organized in the following way: first, the authors will describe the existing theory about project nomination and project selection, including the gaps (inconsistencies) found in theories. Second, roadmaps to nominate and select both reactive and proactive improvement project nomination are presented, followed by an algorithm (and an example) to determine the priority of nominated improvement projects based on the perception regarding the value that each project adds to customers. The paper finalizes with conclusions.

2. Literature Review

2.1 Sources of Project Nomination

According to Juran (1989), the sources of quality improvement can be divided into two areas, which are labeled as “little Q” and “big Q.” The little Q is a narrow view of quality within manufacturing (quality of conformance), where products are defined as the manufactured goods, processes are directly related to the manufacture of goods, customer is the client who buys the products, and cost of poor quality is the costs associated with deficient manufactured goods. On the other hand, the big Q covers a broader sense of quality (quality of design) in all types of industry (e.g. manufacturing, service, government), whether for profit or not. The big Q defines products as goods and services (both for sale or not), the term processes refer to all processes (manufacturing, business, support, etc), customer is everyone who is affected (both internal and external), and cost of poor quality is all costs that would disappear if everything were perfect. New product development, sales forecast, and the fulfillment of customer orders are some examples of areas to address within the scope of big Q.

According to Bothe (2002), the “conventional” Six Sigma methodology operates within the little Q, while the big Q is the scope of operation of the “ultimate” Six Sigma. Therefore, it seems clear that the concept of big Q and little Q is also recognized by the Six Sigma
methodology. However, another way of categorizing the sources (or the scope) of improvement projects, rather than big Q and little Q, might be necessary in order to “guide” organisations in achieving their goals (i.e. to provide value for their customers).

2.2 Approaches for Project Nomination

The opportunities for improvement in the big Q are often identified through market research and/or benchmarking, and the cost of poor quality and/or internal metrics (indicators) can be used as an aid to identify improvement opportunities from the little Q area (Juran, 1989). Looking at a new classification of the firm’s quality cost by Dahlgaard et al. (1998; pp. 206), particularly on the loss of goodwill, leads to the interpretation that little-Q problems and big-Q problems have a “bullwhip” relation, meaning that quality problems caused by manufacturing but found after the products have been shipped to customers will cause bigger and more serious impacts. Therefore, loss of goodwill is a condition or measure (as the consequences of one or repeated “bullwhip” events of quality problem) that can be used to describe the phenomenon of low value, where the quality performance is regarded as low but costs are high.

Within the Six Sigma or Lean Sigma methodology, as well as TQM (see e.g. Dahlgaard and Dahlgaard-Park, 2006), identification of improvement opportunities may start from customer needs and/or strategic business needs (Breyfogle et al., 2001), from gaps in key performance indicators, which reflect the organizational “pain” (Snee, 2005), or customer value (Pyzdek, 2003). Improvement opportunities can then be identified with the help of budget statements and cost of quality studies (Snee, 2001), as well as Balanced Scorecards (George, 2002).

Identifying improvement opportunities from cost of poor quality often requires a utilization of specific provision to analyse data in order to identify problem areas. This provision is a roadmap (or an algorithm), which contains a structured way of analysing data in order to determine the problem and selecting the project in order to solve the problem(s). However, a roadmap needed to choose projects is not always available, and enlarging the accounting system seldom leads to quality improvement (Juran, 1989). In other words, a roadmap that links quality costs and quality improvement projects are often not available. The link is essential if we consider that the following: quality-cost measurements are valuable only if there is a structure of identifying problem areas and selecting projects based on quality cost measurements.

2.3 Criteria of Project Selection

There are several factors that need to be considered when selecting improvement projects. According to Juran (1989), the first project should deal with a chronic problem, and should
give significant and measurable results both in money and technological terms. The projects thereafter should have significant impact on Return on Investment (ROI), the health of the product line, or criteria such as urgency, ease of technological solution, and probable resistance to change. Deming (1986, 2002) emphasizes the importance of reducing or eliminating variation during the improvements. Antony et al. (2004) emphasize that projects should be selected in such a way that they are closely tied to the strategic improvement needs and priorities of the organisation.

2.4 Algorithms/tools for Project Selection

Improvement projects can be selected using algorithms, tools, or metrics such as cost-benefit analysis, weighted scoring, throughput-based method or theory of constraints (see Pyzdek, 2003), Pareto priority index (Juran and Gryna, 1993; in Pyzdek, 2003), and project assessment matrix (Breyfogle et al., 2001). Other tools such as Analytic Hierarchy Process (AHP) and Pareto diagram may also be applicable.

Based on the tools mentioned above, the theory of constraints, that is further developed by Pyzdek (2003) from Goldratt (1990), seems to be a method that explicitly recognizes the elements of customer value (i.e. quality, time, and cost) by selecting improvement projects that are critical-to-quality, critical-to-schedule (time), or critical-to-cost. However, it seems to be insufficient only to consider customer value at a component-level without considering the possibility that those components may interact with each other in constructing the “legitimate” concept of customer value. On the other hand, cost-benefit analysis implicitly describes the concept of customer value (i.e. that value to customers involves a trade-off between benefits and costs), even though there might be a risk that the terms costs and benefits tend to be too much producer-oriented. Thus, existing project selection tools/algorithms, which are widely used within Six Sigma and Lean Production, do not adequately manifest the concept of customer value, even if these tools are often claimed to have a focus on customer value.

3. A New Categorisation and Selection of Improvement Projects

3.1 Reactive Versus Proactive [Quality] Improvements

Both little Q and big Q contain reactive and proactive elements. Reactive in the sense that improvement opportunities are relatively easy to identify because they are mostly visible and/or spoken, which often enable a “straightforward” problem definition and decision in determining the problem that need to be solved first. On the other hand, proactive quality improvements are more difficult to identify since they are usually invisible and/or unspoken,
which involve a more complex problem definition and a decision about which projects should be selected.

Identifying improvement opportunities based on internal failures is an example of reactive little Q improvement, while identifying improvement opportunities based on internal inefficiencies can be described as an example of proactive little Q improvement projects. Improvement projects that are identified from external customer complaints are examples of reactive big Q improvement projects, while improvement projects that are derived from customer dissatisfaction and/or lower customer value are examples of proactive big Q improvement projects. This additional dimension highlights that improvement projects are not only different in terms of scope, but also in character (e.g. problem definition and decision making). However, existing approaches in project selection do not sufficiently provide algorithms of project selection that adequately discriminate proactive improvement projects from reactive improvement projects, which is probably the reason why the approach of Six Sigma’s project selection is not “clear-cut” (George et al., 2004). Hence, the authors of this paper suggest that selecting proactive quality improvement projects need to be distinguished from selecting reactive quality improvement projects.

### 3.2 Provision or Roadmap for Reactive Quality Improvement Projects

Projects that are identified from the narrow definition of cost of poor quality (i.e. scrap or complaints) can be described as reactive quality improvement projects. The following provision or roadmap (see Figure 1) provides an algorithm, a step-by-step identification of improvement opportunities based on the cost of poor quality. It is a process of narrowing a broad area of improvement into a specific problem definition that is manageable in the form of a project, which links quality cost to the quality improvement project.

The roadmap starts with determining variables that can be used to classify the costs due to scrap or complaints, e.g. product type or group, process or machine, etc. Then, a Pareto diagram is used to narrow the problem area and for determining the group that need to be prioritized for improvement by selecting the cost category with the largest cost. The next step is to identify failure types or modes, which can be used as the starting point to nominate several improvement projects. By using this algorithm in project selection, we will be able to determine the rank of priority of each improvement project. It is important that the selected improvement project has a clear connection with customer requirements and/or business strategy. Therefore, starting from the project with the highest priority, the relevance or criticality of each improvement project to customer requirements or business strategy is checked. If the project with the highest priority is critical or relevant in relation to customer requirements or business strategy, it can be declared as the selected improvement project. Otherwise, consider the project with the next highest priority.
3.3 Provision and Algorithm for Proactive Quality Improvement Projects

Added value to customer (AV) is a relevant concept in the proactive approach to select quality improvement projects because when defects or failures are no longer used as the only reference to indicate what to improve, then customer value will provide guidelines for improving products in order to satisfy and retain customers. Hence, improvement projects should be selected based on their potential contributions to customer value (which in this case is perceived by the producer).

Figure 2. A roadmap to select proactive quality improvements

Provision for selecting a proactive quality improvement project (see Figure 2) starts from the identification of “gaps” in key performance indicators (KPI’s), i.e. differences between targets and achieved results. Then, the next step is to identify the potential causes of the gap, which leads to the nomination of improvement projects. The selected and announced
improvement project is the project that is perceived as having the highest added value to customers.

3.4 Algorithm for Selecting Proactive Improvement Projects

Pyzdek’s fundamental ideas of the theory of constraint and cost-benefit analysis should be “merged” in order to develop a “new” method that can be used to select improvement projects. The selection of improvement projects is based on the perception regarding the contributions of the projects in adding value to customers (in terms of quality, time, and costs) and other benefits for the producer, as well as the perception regarding the efforts that the producer needs to make in order to perform the projects. Thus, the “new” method for selecting improvement projects basically assesses the “worth” of performing improvement projects by comparing the benefits gained from the projects and the required efforts to perform the projects.

Perceived added value (PAV) is therefore defined as a ratio between stakeholders’ (or company’s) perception on the overall benefits of the improvement project (OPB) and the perception on the overall efforts required to perform the improvement project (OPE).

\[ PAV = \frac{OPB}{OPE} \] (1)

The overall perceived benefits (OPB) should include several variables, which represent the perceived benefits due to the project’s output (e.g. the impact on quality of product or service, delivery time, cost reduction) and the perceived benefits due to project execution (e.g. the project motivates the cooperation between functions in the organization, the impact on learning, etc).

The overall perceived efforts (OPE) include several variables which represent, e.g. the perception on project resources required, such as time and cost (e.g. perception whether the project is costly or not, perception that the project can be completed within x months), and other efforts that are rather difficult to measure, e.g. efforts to deal with resistance for change or friction in the cooperation. Each variable in OPB is weighted between 0 and 1, so that the sum of weights (w) is equal to 1. The same rule is applicable for OPE.

Before measuring the perception scores using e.g. a 1-7 scale or a 1-10 scale, it is important to define the meaning when a variable has either a “low” score or a “high” score. The following definition is applicable for such a purpose: On the benefits dimension score “1” indicates “low” benefits while score “7” indicates “high” benefits; on the efforts dimension score “1” indicates that the amount of required efforts is “low”, while score “7” indicates high efforts are required. Further, it might be necessary to transform these perception scores into normalized perception scores of benefits (NBP) and normalized scores of percep-
tion on effort ($NPE$), so the results are comparable regardless which measurement scales are used.

Normalized perceived benefits ($NPB$) score is defined as the ratio between the distance of perceived benefits score ($PB$) from the lowest possible score ($PB_{min}$) and the range between highest and lowest possible score in the same scale ($PB_{max}$ and $PB_{min}$ respectively). Then:

$$NPB = \frac{PB - PB_{min}}{PB_{max} - PB_{min}}$$

(2)

Using the same procedure, normalized perceived efforts ($NPE$) could be expressed as:

$$NPE = \frac{PE - PE_{min}}{PE_{max} - PE_{min}}$$

(3)

Thus:

$$PAV = \frac{\sum_{i=1}^{n} w_i * NPB_i}{\sum_{j=1}^{m} w_j * NPB_j}, \text{ in which } PAV \in [0, \infty)$$

(4)

Where:

- $PAV$ : Perceived added value
- $NPB_i$ : Normalised perception score of a certain benefit-related variable
- $w_i$ : The weight of a certain benefit-related variable
- $n$ : Total number of benefit-related variables
- $NPE_i$ : Normalised perception score of a certain effort-related variable
- $w_j$ : The weight of a certain effort-related variable
- $m$ : Total number of effort-related variables

### 3.5 Example

Let’s assume that there are three projects nominated by the improvement team. The team is then going to select a project with the highest priority for improvement. A project has the highest improvement priority if the project has the highest “perceived value added” score, which means that this project has the largest potential for adding value to the customers. The team then lists several variables, both benefit-related and effort-related. Benefit-related variables represent the intended results or conditions, which becomes the reasons why the improvement project is necessary to be performed. Effort-related variables represents the necessary resources in order to perform the improvement project successfully. Some variables might be more important than others, which becomes the reason for giving each variable a certain weight. For each project, the improvement team then gives a score
(using e.g. a 1-10 scale or a 1-7 scale) on those benefit-related and effort-related variables, which are shown by Table 1 and Table 2 respectively.

**Table 1.** Weights and scores of perceived benefits for the nominated projects

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Project 1</th>
<th>Project 2</th>
<th>Project 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PB1</td>
<td>0.25</td>
<td>7</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>PB2</td>
<td>0.2</td>
<td>5</td>
<td>3</td>
<td>6</td>
</tr>
<tr>
<td>PB3</td>
<td>0.4</td>
<td>5</td>
<td>6</td>
<td>6</td>
</tr>
<tr>
<td>PB4</td>
<td>0.15</td>
<td>4</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

**Table 2.** Weights and scores of perceived efforts for the nominated projects

<table>
<thead>
<tr>
<th></th>
<th>Weight</th>
<th>Project 1</th>
<th>Project 2</th>
<th>Project 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE1</td>
<td>0.35</td>
<td>6</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>PE2</td>
<td>0.2</td>
<td>2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>PE3</td>
<td>0.2</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>PE4</td>
<td>0.25</td>
<td>3</td>
<td>4</td>
<td>3</td>
</tr>
</tbody>
</table>

In order to have a similar interpretation whether we use a 1-10 scale or a 1-7 scale, the perceived benefit scores and perceived effort scores need to be normalized. Table 3 and Table 4 shows the normalised scores of perceived benefits and perceived efforts respectively.

**Table 3.** Weights and normalized scores of perceived benefits for nominated projects

<table>
<thead>
<tr>
<th>NPB</th>
<th>Weight</th>
<th>Project 1</th>
<th>Project 2</th>
<th>Project 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPB1</td>
<td>0.25</td>
<td>1.00</td>
<td>0.67</td>
<td>0.17</td>
</tr>
<tr>
<td>NPB2</td>
<td>0.2</td>
<td>0.67</td>
<td>0.33</td>
<td>0.83</td>
</tr>
<tr>
<td>NPB3</td>
<td>0.4</td>
<td>0.67</td>
<td>0.83</td>
<td>0.83</td>
</tr>
<tr>
<td>NPB4</td>
<td>0.15</td>
<td>0.50</td>
<td>0.83</td>
<td>0.67</td>
</tr>
<tr>
<td>Total</td>
<td>0.72</td>
<td>0.69</td>
<td>0.64</td>
<td></td>
</tr>
</tbody>
</table>

**Table 4.** Weights and normalized score of perceived efforts for nominated projects

<table>
<thead>
<tr>
<th>NPE</th>
<th>Weight</th>
<th>Project 1</th>
<th>Project 2</th>
<th>Project 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>NPE1</td>
<td>0.35</td>
<td>0.83</td>
<td>0.67</td>
<td>0.17</td>
</tr>
<tr>
<td>NPE2</td>
<td>0.2</td>
<td>0.17</td>
<td>0.17</td>
<td>0.50</td>
</tr>
<tr>
<td>NPE3</td>
<td>0.2</td>
<td>0.50</td>
<td>0.67</td>
<td>0.83</td>
</tr>
<tr>
<td>NPE4</td>
<td>0.25</td>
<td>0.33</td>
<td>0.50</td>
<td>0.33</td>
</tr>
<tr>
<td>Total</td>
<td>0.51</td>
<td>0.52</td>
<td>0.41</td>
<td></td>
</tr>
</tbody>
</table>

We are now able to calculate the perceived-value-added score for each nominated project, which is shown by Table 5.
Table 5. The perceived added value to customer for the nominated projects

<table>
<thead>
<tr>
<th>Project</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.43</td>
</tr>
<tr>
<td>2</td>
<td>1.32</td>
</tr>
<tr>
<td>3</td>
<td>1.57</td>
</tr>
</tbody>
</table>

Since project 3 has the highest score on added value to customers this project should be selected.

4. Conclusions

Performance measurements, such as quality costs, are often useful to identify the opportunities of improving quality performance. However, the roadmap that links the measurements to improvement projects is not always available. The nominated improvement projects usually become the way to find solution for a problem, which are identified based on the area problem that occurs in the production process (little Q) or in the business process (big Q). Selecting an improvement project among several nominated projects is not an easy task. Therefore, it must be done wisely with the help of various project selection approaches.

According to Six Sigma and Lean Production improvement methodologies, improvement projects are not merely the way to solve problems, but also the way to improve customer satisfaction and customer value. The orientation towards customer value brings a new view on performance improvement, that improvements should not only be reactive (solving problems) but also be proactive (a better performance to satisfy customers and provide more value). Therefore, the attempts to improve quality and performance should be both reactive and proactive, where the selected project is the project with the largest potential to add value to customers. Both reactive and proactive improvements require a roadmap that connects performance indicators and improvement projects. Improving quality performance proactively means that customer value is the main consideration when determining the priority of nominated improvement projects and selecting the project to work with.

References

Abstract

Purpose – The paper suggests a method to operationalise the concept of customer value and to monitor producer’s own performance in creating/delivering customer value.

Design/methodology/approach – Prior to the operationalisation of customer value and monitoring customer value performance, customer value is viewed through system thinking in order to deal with different variations in relation with the customer value concept. The algorithm to transform customer value into flowing values along the value stream includes the measurement of customer value, segmenting customers based on their value perceptions, identifying critical values, and finding attributes that are linked to critical values. The applicability of the suggested algorithm is demonstrated through simulation. Control chart can be adapted as a tool to monitor producer’s performance in creating and delivering fair customer value.

Findings - Functional utilities are the most appropriate “surrogate” of values in the sense that those are defined by customers but still can be influenced by the producer. The algorithm will enable the producer to focus on the values that the customers consider as crucial as well as determining critical attributes leading to those values. The control limits are producer’s approximation of the “zone of fairness” and the limits of the control chart should be set narrower than three sigma if a producer seeks a higher capability in creating/delivering customer value.

Research implication - The operationalisation of customer value concept is relevant for research in quality management (particularly Quality Function Deployment (QFD), Six Sigma, and Lean Production). The idea of monitoring customer value is relevant for research in marketing, where customer value is related to supplier’s competence (value creation potential).

Originality/value - This paper provides insights and develop methods to understand and interpret the customer value concept, identifying attributes that are critical to create value, as well as to demonstrate and monitor own performance in creating/delivering value.

Keywords: customer value, customer knowledge, functional utilities, system thinking, value monitoring.

Category: conceptual paper

Introduction

Although value is an important concept, many companies often do not know how to define and/or measure value (Anderson and Narus, 1998; Lindgren and Wynstra, 2005). According to Bounds et al (1994), the ability to create superior value to customers requires at least three kinds of knowledge: customer knowledge (knowledge of customer needs, desires, and how customers use products or services), subject matter knowledge (scientific, engineering, and social knowledge required to be able to produce the product or service), and self-knowledge (knowledge regarding
the mechanisms and capabilities of an organisational system to deliver value as well as the knowledge to improve the system). These three types of knowledge are important for organisations as value-creating systems.

In the field of quality management, it seems that the subject matter knowledge and the self-knowledge are well developed but the customer knowledge is the least explored. Quality Function Deployment (QFD), for example, although it starts with the identification of what customer needs/wants, the focus of the later stages is much more on the existence or performance of product/service attributes instead of if those attributes help customers to fulfil their needs/wants. Other “evidence” is regarding the practice of Lean Production methodology, although it starts with understanding customer value (as defined by the ultimate customers), the value definition seems to be distorted (Womack and Jones, 2003) because: 1) value is about what the producer can/wants to produce instead of what the customer needs/wants, and 2) value is translated as the absence of “waste” instead of fulfilment of customer needs/wants. Therefore, Womack and Jones (2003) further recommend challenging the "traditional" definition of value in Lean Production and fundamentally rethink value from the perspective of customers.

The above explanation generates a basic question of why customer knowledge is the least explored in the field of quality management? Maklan and Knox (1997) offer an answer to this question by providing a critical view about TQM, that it is "...originated in system thinking and not from a profound understanding of customers..." (p. 125). However, it seems that their statement does not provide a well-grounded explanation because one of the TQM principles is focus on customers and according to Senge (1990), system thinking is about seeing the processes and interrelationships (in this case, between producers and customers). Thus, TQM (and system thinking) does take customers into account. Instead, the explanation offered by Bathie and Sarkar (2002), that it is not easy to translate and operate the concept of customer focus, may be a more reasonable answer to the above question.

Quality management as an important element in customer value creation should provide a frame of reference to interpret customer value based on customer knowledge, to identify the critical elements to create those values, and to measure/demonstrate the performance in creating/delivering value to customers. Therefore, the purpose of this paper is to propose a method to operationalise the concept of customer value into value that can flow along the value stream as well as to monitor producer’s own performance in creating/delivering customer value.

Theoretical review on methods to map customer value
Hierarchical value map (means-ends model)
The means-ends model is a qualitative market research tool to better understand the customers by identifying the values behind customer opinions (Edvardsson and Gustafsson, 1999). The hierarchical value map or means-ends theory (in e.g. Bounds et al, 1993) suggests that the acquisition or the consumption of a product is a means to achieve certain ends or to accomplish what users value (such as needs, goals, desires). Thus, the hierarchical value map or the means-ends model is a method to gain customer knowledge, where value to customers depends on the degree of compatibility (match) between the consequences of using the product and customer needs.
The means-ends model simply describes that product attributes will have consequences that enable the fulfilment of needs or goals. In fact, the consequences can be further stated as **functional and psychosocial utilities** (figure 1). However, the term "consequences" focuses mainly on the benefit-side and less on the sacrifice-side, which seems to be a shortcoming of the means-ends model because the customers (of e.g. wood-flooring products) do consider life cycle costs.

![Figure 1. The means-ends model](image)

**The "conventional" customer value map**

The customer value map (Gale, 1994) is a (quantitative) tool to analyse whether a product or a company has provided superior customer value (relative to its competitors) by plotting (in a diagram) *market perceived quality* (MPQ) against *market perceived price* (MPP) (see figure 2). MPQ may be estimated by the sum of multiplications between a *performance scores ratio* and *importance weight* [usually collected using surveys or interviews] on each quality attribute, for example safety, durability, and availability (Gale, 1994). Thus, MPQ can be expressed as:

\[
MPQ = \sum_{i=1}^{n} R_i * w_i
\]

Where:
R<sub>i</sub>: The performance score of quality attribute i of a product relative to its competitor(s)
w<sub>i</sub>: The importance weight of quality attribute i
i: 1, 2, 3, ..., n

MPP is calculated in the same way as MPQ; the difference is that MPP is applicable on price attributes such as purchase price, trade-in allowance, resale price, and interest rates. In other words:

\[
MPP = \sum_{j=1}^{m} R_j * w_j
\]
Where:
R\textsubscript{j}: The performance score of price attribute j of a product relative to its competitor(s)
w\textsubscript{j}: The importance weight of price attribute j
j: 1, 2, 3, …, m

\begin{figure}[h]
\centering
\includegraphics[width=0.5\textwidth]{customer_value_map.png}
\caption{The "old" customer value map}
\end{figure}

Gale (1994, p. 83) illustrates the fair value zone as the area where the ratio between MPQ and MPP is approximately 1, meaning that customers perceive a product with a certain quality level worth to be bought at its current price level. Outside this zone, a product (or firm) provides more or less value (depending on the location of the point).

**Customer value in the non-competition context**
Doyle (1995) and Maklan and Knox (1997) discuss sustainable customer value over time, which is about focusing more on the customers themselves and the fulfilment of their needs/goals and less on competition in the market (Johnson and Weinstein, 2004). Thus, sustainable customer value over time implies the necessity of "continuous" measurement and monitoring.

Although repetitive measurements of customer value are possible, Gale (1994) neither discusses sustainability nor suggests that customer value should be continuously monitored. Moreover, Gale discusses customer value in the context of competition [positioning of a company or a product in the market in comparison with other competing products or companies], which is more about if a product gives more than its competitors rather than if a product gives the customers what they need/want. This situation could be dangerous because although the value map is intended as a tool to explore customers' perceptions about the value of a product, the reference of comparison is not the customers’ needs/wants but the competing products. In contrast:

“…delivering superior value to our customers is not about beating our competition. Focusing on the competition as the basis of improving our business with customers could and would prevent us from truly understanding our customers and discovering unique insights about how we can help them to succeed better. Also, focusing on the competition would trap us in a common shared point of view about customers and our market rather than developing breakthrough ideas” (in Johnson and Weinstein, 2004; p. 272).
Increasing attention towards customer focus and customer relationships elevate producers’ interest to find out: 1) whether the product(s) have constantly and/or consistently provided fair value to customers over time, 2) whether the value provided by their products is increasing or decreasing. Measuring customer value in the context of non-competition (referred to as received customer value) requires a reengineering of the "conventional" value measurement. The re-engineered value measurement might become a self-evaluation method to monitor own performance (or reputation) in providing value to customers and encourage proactive actions to assure that the value provided is considered as fair for both the producer and the customers. Hence, the producer will have a "genuine" focus on customers and customer relationships and will be actively engaged in the customer value "issue". Customer value monitoring will further be discussed later in this paper.

Transforming customer value into values that flow in the value stream
The identification of customer value can not ignore the fact that there is variation regarding people's thinking or perceptions, which means that people perceive things differently and what is important for someone might not be important for someone else. In fact, managing the downstream variation (volatility), e.g. customers, market, price, etc will be the next challenge for quality management (Williams et al, 2006).

This makes value "... very hard for producers to accurately define" (Womack and Jones, 2003; p. 16), which may lead to a mismatch between customer values and values that are inherent in the product or service attributes as created by the producers. Therefore, managing these two types of variations (i.e. variation within customers and variation between producer and customers), by adapting the perspective of system thinking (Senge, 1990), is important when transforming customer value into values that flow along the value stream.

Variation in customers’ thinking (perception)
In the perspective of system thinking, variation is distinguished into stable and unstable variation (Shewhart, 1931). Unstable variation is an unwanted condition that is caused by special causes. Through improvements (by identifying and eliminating special causes) unstable variation can be controlled statistically and hence changed into a condition of stable variation.

The existence of variation in customers and their use of products or services make the fulfilment of customer needs/wants an uneasy task (Bounds et al, 1993). The causes of customer variation are impossible to control or to eliminate. Therefore, customer-related variation should be managed. Managing customer variation can be done through segmentation because in this way, it is possible to increase the homogeneity of customers within segments and the heterogeneity between customer segments. Here, we adapt the art of system thinking to simplify the complex idiosyncratic reality of customer value by assuming that significant variations exist between segments.

Customer perceptions about what customers value should be the basis of segmentation. Perceptions about customer value can be explored and mapped using the means-ends model. However, the means-ends model may not be a good basis for segmenting customers because: 1) it is subjective and qualitative, and 2) unrepresentative because it emphasises more on the benefit “side” of consequences.
Therefore, the re-engineered value map may be an appropriate tool for segmentation because: 1) it is quantitative, 2) both the benefits and sacrifices reflect the consequences of using the product.

Variation in producers' and customers way of defining value
Womack and Jones (2003) and Möller (2006) highlight the dilemma in interpreting value. Suppliers and customers do not always agree on what constitutes "value" (the value paradox). Value from the customers' perspective is about the fulfilment of needs or wants as the consequences of using or consuming products, while value from the producer's perspective is about creating products or services with attributes aimed to fulfil customer needs. Thus, the problem in interpreting value stems from the fact that the producer and the customers view value from opposite directions. Therefore, it is necessary to find a "compromise" definition of value.

Lindgren and Wynstra (2005) highlight the difference between [consumer] "value" and "values", which can be used as a basis to find a compromised definition of value. Value refers to a preferential judgement like an interactive relativistic preference experience, which is the result of a trade-off between benefits and sacrifices. Interactive refers to the interaction between objects and subjects (persons), while relativistic refers to: comparison of objects, subjective according to the person, and situation/context-dependent (Holbrook, 1999; pp. 5-6). Values refer to the criteria by which such preferential judgments are made, which thus become deeply held and enduring beliefs, which [at a lower level of abstraction] manifest into desired product attributes (Flint et al, 1997).

Therefore, a compromised customer value definition should be derived from customer “values”, which then requires us to find the right "level" in the hierarchical value map where value is perceivable by the customers but still can be influenced by the producer. Hence, [compromised] customer value is related to the consequences of product attributes or characteristics that will become the basis for the customer to make a preferential judgement, whether a product or service will likely fulfil their goals/needs/wants or not.

Considering this compromised definition of value, it is suggested that functional utilities, i.e. the usefulness or the outcomes as the consequences of using a product (Hermann and Huber, 2000; Reynolds and Olson, 2001) seem to be the most suitable "surrogate" for customer values. This compromised definition of values is consistent with the principle of system thinking (Senge, 1990) in the sense that it takes into account the interrelationship between producers and customers.

Algorithm to transform customer value into flowing values along value stream
Transforming customer value into values that flow along the value stream is basically about identifying product (or quality) characteristics/attributes that lead to critical values (functional utilities). In Six Sigma, these flowing values are recognised as critical to quality, which are often determined subjectively and less connected to customer value. Considering customer value as the ultimate goal of Six Sigma, the critical to quality should be truly critical for creating value to customers.

Identifying the critical to quality that is critical to value requires a transformation of customer value, from a cognitive-individual matter into a tangible-operational matter.
The transformation starts with measurements of customer value. Then, customers are segmented according to their value perceptions. Next, critical values (functional utilities) in different segments are identified. Finally, the attributes that are linked to the critical values are identified. Before demonstrating the transformation process more in detail, the variables, data, and sampling procedure will first be described.

**Variables, data, and sampling procedure**

In order to measure customer value (defined as a ratio between benefits and sacrifices), we need to define the functional utilities (which represent the benefits) in terms of operating variables and identify the components of life cycle costs (which represent the sacrifices). Defining functional utilities in terms of operating variables requires a construction of a hierarchical value map (means-ends model). However, in this paper, fictive variables are used (see figure 3). Thus, the variables of functional utilities are identified as U₁, U₂, U₃, and U₄. While the life cycle cost includes C₁, C₂, C₃, and C₄.

![Means-ends model of customer value](image)

The sample size will be \((n*k)\) customers, meaning that the perceptions of \(n\) customers are identified in each period for \(k\) periods. Each customer perceives both the importance and performance of each variable (U₁, U₂, U₃, U₄, C₁, C₂, C₃, and C₄) on a 1-7 scale. Hence, there are 16 sets of data for each customer.

These 16 data sets have been simultaneously generated using random numbers (between 0 and 1) which were multiplied by the maximum number of the measurement scale used (i.e. 7 in this case) and rounded in order to get integers. If a zero appeared, it was replaced by a new generated number. Assuming that \(n = 9\) and \(k = 20\), the procedure was repeated 180 times (= 9*20) to represent the data of 180 customers.

Before calculating customer value, the data were normalised, meaning that a score is subtracted by the lowest score in the measurement scale and then divided by the range of measurement scale. Table I shows the averages of the generated importance weights and performance scores of functional utilities (Uᵢ) and cost components (Cᵢ).
Table I. Average importance weights and performance scores of $U_i$ and $C_i$

<table>
<thead>
<tr>
<th>Importance weight</th>
<th>Performance</th>
<th>Importance weight</th>
<th>Performance</th>
</tr>
</thead>
<tbody>
<tr>
<td>$U_1$</td>
<td>0.2811</td>
<td>$C_1$</td>
<td>0.2242</td>
</tr>
<tr>
<td>$U_2$</td>
<td>0.2522</td>
<td>$C_2$</td>
<td>0.2412</td>
</tr>
<tr>
<td>$U_3$</td>
<td>0.2254</td>
<td>$C_3$</td>
<td>0.2598</td>
</tr>
<tr>
<td>$U_4$</td>
<td>0.2413</td>
<td>$C_4$</td>
<td>0.2747</td>
</tr>
</tbody>
</table>

Sum = 1

Calculate customer value

Here, customer value is measured in the context of non-competition defined as received customer value (RCV). The measurement of RCV is basically a “reengineering” of the value measurement by Gale (1994) in the sense that: 1) value is calculated for each individual customer (instead of calculating value as a ratio between average customers’ perceptions on benefits and sacrifices), 2) instead of collecting a relatively large sample at once, the samples are collected for $k$ periods at a smaller sample size, and 3) the benefits and sacrifices reflect on customer’s use situation (instead of purchase situation).

At sampling period $t$, the individual customer judgments about the value of a product can be calculated as:

$$RCV_i = \frac{U_i}{C_i} = \frac{\sum_{j=1}^{m} w(u_j) \cdot u_j}{\sum_{h=1}^{g} w(c_h) \cdot c_h} \quad (3)$$

Where:

- $RCV_i$ : Individual customer value of customer $i$ ($i = 1, 2, \ldots, n$)
- $U_i$ : Customer’s individual cognitive judgement on the product’s functional utilities
- $C_i$ : Customer’s individual cognitive judgement on the product’s life cycle costs
- $w(u_j)$ : Weight of functional utility $j$ ($j = 1, 2, \ldots, m$)
- $u_j$ : Performance score of functional utility $j$
- $w(c_h)$ : Weight of cost component $h$ ($h = 1, 2, \ldots, g$)
- $c_h$ : Performance score of cost components $h$
- $m$ : Number of functional utilities
- $g$ : Number of cost components

Based on table I, the overall mean and standard deviation of customer value, calculated according to equation (3) are 1.1597 and 0.5426 respectively. The overall mean of customer value indicates that customers, in general, perceive the value as fair or may be as high.

Value-based segmentation

Segmenting customers based on value can be done using for example K-Means Cluster Analysis (see e.g. Hair et al, 1998) with the help of statistical software such as SPSS, where the $U_i$ and $C_i$ are the discriminating variables. The purpose of the segmentation is to classify customers into high-, fair-, and low-value segments.
The data analysis suggests that high-value segment generally perceives that the performance of the functional utilities is higher than the importance; this segment neither considers that low product cost is important nor perceives the product as costly. Fair-value segment generally perceives that the performance of functional utilities is lower than the importance, although this segment does not consider the product as costly or considers having low-cost as important. Low-value segment generally perceives the performance of functional utility as higher than the importance, but this segment perceives that the product cost is significantly higher than expected.

Table II shows the descriptive statistics and the normalised importance score of functional utilities in each segment.

<table>
<thead>
<tr>
<th>Segment</th>
<th>N</th>
<th>Mean</th>
<th>Median</th>
<th>St. dev</th>
<th>U1</th>
<th>U2</th>
<th>U3</th>
<th>U4</th>
<th>Max (Uj)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High-value</td>
<td>50</td>
<td>1.7056</td>
<td>1.6300</td>
<td>0.4501</td>
<td>0.4300</td>
<td>0.4300</td>
<td>0.4400</td>
<td>0.4933</td>
<td></td>
</tr>
<tr>
<td>Fair-value</td>
<td>54</td>
<td>1.1852</td>
<td>1.0400</td>
<td>0.5313</td>
<td>0.4558</td>
<td>0.3865</td>
<td>0.4120</td>
<td>0.5220</td>
<td></td>
</tr>
<tr>
<td>Low-value</td>
<td>76</td>
<td>0.7825</td>
<td>0.7900</td>
<td>0.1646</td>
<td>0.4351</td>
<td>0.3506</td>
<td>0.3874</td>
<td>0.4351</td>
<td></td>
</tr>
</tbody>
</table>

Table II indicates that the highest (maximum) importance scores of functional utilities do not always come from the high-value segment because the high-value segment has lower importance scores on U₁ and U₂ (but higher importance scores on U₃ and U₄) than the fair-value segment. Moreover, it should be noted that high, fair, or low perception of value in a segment is not determined only by the importance scores of functional utilities, but by the combination of both the importance and performance scores on functional utilities and costs.

**Identify critical to value for each customer segment**

A value (functional utility) is critical for a particular segment when it has a higher priority in a segment than by all segments. Hence, the comparison between the *priority rate* of a value (functional utility) in a certain segment with the *overall priority rate* of this value will determine whether a value is critical or not. The term “priority rate” describes the level or position of a value in comparison with the most important value (as judged by customers); it does not refer to the proportion or weight of a value relative to all values as a “whole”. This logic applies because, when identifying the critical-value-to-customers, the question asked should be: “how much do customers prioritise a value?” and not “how much does a value contribute to the “whole”? “.

In order to identify the critical values in a certain segment, it is required to first calculate the segment’s priority rate for each functional utility. Then, calculate the overall priority rate of every functional utility. Finally, (for each functional utility) compare between a segment’s priority rate and the overall priority rate.
A segment’s priority rate on functional utility j \((PR_{j_{\text{segment}}})\) is the ratio between a segment’s average importance score and the highest important score of all functional utilities in a segment. Thus:

\[
PR_{j_{\text{segment}}} = \frac{I_{j_{\text{segment}}}}{I_{\text{max}_{\text{segment}}}}; \quad 0 \leq PR_{j_{\text{segment}}} \leq 1 \tag{4}
\]

Where:
- \(I_{j_{\text{segment}}}\): The importance score of functional utility j judged by a customer segment
- \(I_{\text{max}_{\text{segment}}}\): The highest importance score of \(I_{j_{\text{segment}}}\)

Equation (4) suggests that the functional utility with the highest importance score has priority rate equal to one (1), and each of the remaining functional utilities will be scored less than one. Hence, the sum of the priority rates of all functional utilities is not equal to one.

The calculation of the priority rate of functional utilities in different segments is shown in table III. Example: from table III, the importance score of functional utility 2 (U2) in the “high-value” segment is 0.4300, and the highest importance score of all functional utilities in this segment is 0.4933. Then, the priority rate of functional utility 2 (U2) is 0.4300/0.4933 = 0.8717. Since the importance score of U1 is equal to the highest importance score of all functional utilities (= 0.4933), then \(PR(U_1) = 1\).

<table>
<thead>
<tr>
<th>Segment</th>
<th>High-value</th>
<th>Fair-value</th>
<th>Low-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>(PR(U_1))</td>
<td>=0.4933/0.4933 =1</td>
<td>=0.5220/0.5220 = 1</td>
<td>= 0.4351/0.4351 = 1</td>
</tr>
<tr>
<td>(PR(U_2))</td>
<td>=0.4300/0.4933 =0.8717</td>
<td>=0.4558/0.5220= 0.8732</td>
<td>= 0.4069/0.4351= 0.9352</td>
</tr>
<tr>
<td>(PR(U_3))</td>
<td>=0.4300/0.4933 =0.8717</td>
<td>=0.3865/0.5220= 0.7404</td>
<td>= 0.3506/0.4351= 0.8058</td>
</tr>
<tr>
<td>(PR(U_4))</td>
<td>=0.4400/0.4933 =0.8920</td>
<td>=0.4120/0.5220= 0.7893</td>
<td>= 0.3874/0.4351= 0.8904</td>
</tr>
</tbody>
</table>

The overall priority rate of functional utility j \((PR_{j_{\text{overall}}})\) is the ratio between the overall (all segments’) important score of utility j and the highest overall importance score of all functional utilities. Hence:

\[
PR_{j_{\text{overall}}} = \frac{I_{j_{\text{overall}}}}{I_{\text{max}_{\text{overall}}}} = \frac{1}{r} \sum_{j=1}^{r} \frac{I_{j_{\text{overall}}}}{\text{Max}(I_{j_{\text{overall}}})} \tag{5}
\]

Where:
- \(I_{j_{\text{overall}}}\): The average importance score of functional utility j for all customer segments
- \(I_{\text{max}_{\text{overall}}}\): The highest overall importance score of \(I_{j_{\text{overall}}}\)
- \(r\) = number of segments = 3

Equation (5) also suggests that the functional utility with the highest importance score has priority rate equal to one (1), and each of the remaining functional utilities will be scored less than one. Hence, the sum of the priority rates of all functional utilities is not equal to one.
The calculation of the overall priority rate of functional utilities is shown in table IV. Example: the overall importance score of functional utility 2 (U 2) is 0.4278 and the highest overall importance score of all functional utilities is 0.4768. Therefore, the overall relative importance of functional utility 2 (U 2) is 0.4278/0.4768 = 0.8972. Since the average importance score of U 2 is the same as the average importance score of U3, then PR (U 3) = PR (U 2).

Table IV. The overall priority rates

<table>
<thead>
<tr>
<th>Mean (Uj)</th>
<th>PR (Uj)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1 0.4768</td>
<td>0.4768 / 0.4768 = 1</td>
</tr>
<tr>
<td>U2 0.4278</td>
<td>0.4278 / 0.4768 = 0.8972</td>
</tr>
<tr>
<td>U3 0.3824</td>
<td>0.3824 / 0.4768 = 0.8020</td>
</tr>
<tr>
<td>U4 0.4093</td>
<td>0.4093 / 0.4768 = 0.8584</td>
</tr>
<tr>
<td>Max 0.4768</td>
<td></td>
</tr>
</tbody>
</table>

Note: Max = Max (Mean (Uj)); PR (Uj) = [Mean (Uj)]/Max

A segment considers that a value (a functional utility) is critical if the priority rate of this functional utility is the same or higher than its overall priority rate. Thus:

\[ PR_{j, \text{segment}} \geq PR_{j, \text{overall}} \]  

Where:

- \( PR_{j, \text{segment}} \): a segment’s priority rate of functional utility j
- \( PR_{j, \text{overall}} \): overall priority rate of functional utility j

By comparing each segment’s priority rate of functional utilities (table III) with the overall priority rates (table IV), the critical functional utilities in different segments can be identified using equation (6), which are written in bold (in table III). Example: U 2 is critical for the “low-value” segment because the priority rate of U 2 in the low-value segment is higher than the overall priority rate (i.e. 0.9352 > 0.8972). Critical values in different segments are indicated by table V.

Table V. Critical values in respective segments

<table>
<thead>
<tr>
<th>High value</th>
<th>Fair-value</th>
<th>Low-value</th>
<th>Criticality rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>U1 Critical</td>
<td>Critical</td>
<td>Critical</td>
<td>1</td>
</tr>
<tr>
<td>U2 -</td>
<td>-</td>
<td>Critical</td>
<td>4</td>
</tr>
<tr>
<td>U3 Critical</td>
<td>-</td>
<td>Critical</td>
<td>2.5</td>
</tr>
<tr>
<td>U4 Critical</td>
<td>-</td>
<td>Critical</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Next, the criticality of the values should be ranked and the value with the highest criticality rank should be determined before assigning the critical-to-quality (CTQ) attributes. In this paper, the criticality rank is determined subjectively, in the sense that the more segments consider a value as critical, the higher the rank/priority. Table V shows that U 1 is critical for all segments, U 2 is critical only for low-value segment, U 3 and U 4 are critical for both high-value and low-value segments. Hence, it may be said that U 1 is a value with the highest criticality rank, U 3 and U 4 are at the same level.
of criticality, and U2 has the lowest criticality rank. The criticality rank of U3 is lower than, e.g. U3 although U2 has higher importance weight than U3. This means that although a functional utility is generally judged as more important than another functional utility, it does not necessarily mean that the first mentioned utility has a higher rank of criticality.

When the value with the highest criticality rank has been identified (which is U1 from the description above), the attributes that are linked or associated with the critical value can be found with the help of the means-ends model. These attributes (in this case, A1 and A2) are thus the critical-to-quality or the high-priority value that must “smoothly” flow along the value stream in order to achieve “perfect” quality (zero defect, six sigma quality). If more CTQ attributes are preferred, the next critical value (let’s say U3) can be regarded as the most critical values (together with U1). Then, the attributes that are linked to this value (A3 and A5) can be added into the previously determined CTQ attributes.

The advantages of identifying CTQ attributes using the above algorithm are: 1) it involves a higher degree of objectivity, 2) is customer oriented, and 3) can identify multiple CTQ attributes. Meanwhile, a higher degree of complexity might be the disadvantage of this method.

**Customer value monitoring**

The fact that customer value changes over time makes the segments dynamic in the sense that the notion of “fair” value may change as well. When the value is below the fair zone, it is unfair for the customers (due to unfulfilled needs or too costly product), but when the value is above the fair zone, it delights customers but it may be unfair for the producer due to consumption of more than needed resources. Thus, it is necessary for the producer to approximate the fair value zone (to be described below) in order to reach a win-win situation.

According to Berghman et al (2006) and Möller (2006), customer value creation is related to suppliers' competence or capacity. This competence or capacity will be manifested into specific capabilities of the product as an important element when expressing value to customers according to the Lean Production methodology (Womack and Jones, 1996). Considering that specific product capabilities are created through processes, customer value creation can be seen from a process perspective. This implies that: 1) a control chart can be adapted as a tool to monitor producers’ performance in creating/delivering value to customers, where the control limits define the approximated fair value zone (seen from producer’s perspective), and 2) process capability may indicate suppliers’ competence/capability in the value creation process.

Therefore, the fair value zone is defined by the control limits of a control chart, which is expressed as:

\[
CV \pm \frac{3s}{\sqrt{n}}
\]  

(7)

The overall score of customer value (\(\overline{CV}\)) is defined as:
\[
CV = \frac{\sum_{i=1}^{k} \sum_{t=1}^{n} CV_{it}}{k \times n}
\]  
(8)

Where:
CV_{it} : Individual customer value from customer i at period t
n : Number of customers sampled in each period
k : Number of sampling periods

While the standard deviation (s) of CV is:
\[
s = \sqrt{\frac{\sum_{i=1}^{k} \sum_{t=1}^{n} (CV_{it} - CV_{t})^2}{n \times (k - 1)}}
\]  
(9)

CV_{t} is the average customer value at period t, which is calculated as:
\[
CV_{t} = \frac{\sum_{i=1}^{n} CV_{it}}{n}
\]  
(10)

Thus, the upper limit of the control chart is 1.7156 and the lower limit is 0.6038. Comparing between the limits of the control chart and the average measurements of customer value in each segment “confirms” that the control limits are producer’s approximation of the fair value zone.

Figure 4 shows the plot of weekly fictive customer data. It is seen that there are no measurement points outside the control limits. A point above the upper control limit may indicate that: 1) the product suits well to customers’ use situations or 2) customers do not perceive the product as costly. Thus, the producer knows the strengths of the product and uses those for e.g. marketing purpose. On the other hand, a point below the lower control limit may indicate that: 1) the product does not really fit to customers’ use situations (due to either producer’s inadequate understanding about customer needs or customer’s inadequate understanding (mistake) when using the product), or 2) customers perceive the product as too costly. Therefore, the producer can identify the weaknesses of the product and opportunities to improve it.
Figure 4. Control chart for customer value

Usually, it is necessary to complement the use of the $\bar{X}$-chart with a $s$-chart.

Assuming that customers set the specification limits of the fair value as $\pm 3\sigma$, the adjusted capability index ($C_{pk}$) of producer’s value creating process is equal to one (1). This implies that although producer is capable to create/deliver fair value, the capability just fulfils the minimum requirement. Consequently, the control limits should be set narrower than $3\sigma$ if the producers seek for higher capability in the customer value creation/delivery process (under the circumstances that customers’ specification limits of fair value remain at $\pm 3\sigma$ and that there is no measurement outside the control limits).

Conclusion

Organisation as a system that creates value to customers should possess three different kinds of knowledge: customer knowledge, subject matter knowledge, and self-knowledge. Among these three types of knowledge, customer knowledge is the least explored and least used by organisations as value-creating systems, which may be caused by the difficulty of managing variation in customer perceptions and the fact that customers and producers view value from two different angles.

In order to enable the producer to create value, there should be a compromising definition of value that considers both producers’ and customers' perspectives (interests). Therefore, functional utility seems to be appropriate to represent value because it involves customer perceptions and yet allows producer’s influence.

Using the "new" customer value measure, the producer would be able to manage variation among customers by segmenting the customers according to their perception of value and then identify the unique values that they appreciate using criticality analysis. Identifying critical customer values provides direction for the producers in order to determine which attributes that should be continuously strived towards perfection. Finally, producers can monitor their performance in the value creation process using control charts.
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